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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : David D. Koester et al.

Appeal No. _____

Serial No.: 09/751,669

Filed : December 29, 2000

Group Art Unit: 2652

For : MACHINING ACTUATOR PERIPHERY
TO REDUCE RESONANCE VARIATION

Examiner: Tianjie
Chen

Docket No.: S01.12-0697/STL 9565

**SECOND REQUEST FOR REINSTATEMENT OF APPEAL UNDER
M.P.E.P. §1208.02**

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

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THIS

19 DAY OF Nov. 20 04

Don D. Brush

PATENT ATTORNEY

Sir:

Applicants would like to thank the examiner for the indicated allowability of claims 19-21, and request reconsideration and allowance of remaining claims 13, 17 and 18.

Since no new grounds of rejection were presented with respect to remaining claims 13, 17 and 18, Applicants respectfully request reinstatement of the Appeal in the above-identified patent application. Enclosed with this request is a Second Supplemental Appeal Brief addressing the current grounds of rejection.

WESTMAN, CHAMPLIN & KELLY, P.A.

By: *David D. Brush*

David D. Brush, Reg. No. 34,557
Suite 1600 - International Centre
900 Second Avenue South
Minneapolis, Minnesota 55402-3319
Phone: (612) 334-3222 Fax: (612) 334-3312

DDB:



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SECOND SUPPLEMENTAL BRIEF FOR APPELLANT

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19 DAY OF Nov. 2004


PATENT ATTORNEY

Sir:

This is an appeal from a rejection of the claims in an Office Action dated August 19, 2004, which re-opened prosecution following an earlier appeal and an earlier request for reinstatement. This Second Supplemental Brief is being submitted with a further request for reinstatement of the appeal under M.P.E.P. §1208.02.

REAL PARTY IN INTEREST

Seagate Technology LLC, a corporation organized under the laws of the State of Delaware, and having offices at 920 Disc Drive, Scotts Valley, CA 95067, has acquired the entire right, title and interest in and to the invention, the application, and any and all patents to be obtained therefore, as set forth in the Assignment filed with the Patent Application and recorded on Reel 011615/Frame 0445.

RELATED APPEALS AND INTERFERENCES

Applicants are aware of no related appeals or interferences.

STATUS OF THE CLAIMS

Claims 13 and 17-21 are pending in the application and

stand rejected based on cited references. Claims 1-12 are withdrawn as being directed to a non-elected invention, and claims 14-16 are canceled.

STATUS OF AMENDMENTS

An Amendment-After-Final was filed March 14, 2003, which was entered.

SUMMARY OF CLAIMED SUBJECT MATTER

I. BACKGROUND OF THE INVENTION

The present invention relates to reducing resonance vibration of an actuator in a data storage system. (Page 1, lines 10-12).

The mechanical structure of a data storage system, such as a disc drive, is composed of multiple mechanical components that are pieced together to form the final assembly. Each of these components has various resonant modes that if excited by an external energy source will cause the part to physically move (resonate) at the resonance frequencies of oscillation for the component in question. One component that contributes greatly to such resonant vibration is the actuator. If a component is highly undamped, it will tend to oscillate with a minimal external driving energy. This oscillation results in physical motion of the data head, causing off track errors and potential fly height problems. (Page 2, lines 3-14).

Various schemes can be employed to damp the mechanical components and thereby decrease the amplitude of the resonant mode. Many such resonance-reducing techniques make use of information regarding the resonance characteristics of the disc drive mechanical structure. If the resonance characteristics vary greatly from one drive to the next among a production line, the resonance characteristics data used by the resonance-reducing scheme are likely to be inaccurate. Thus, reducing the variance in the resonance characteristics from one drive to the next will

increase the accuracy of the resonance-reducing scheme. (Page 2, line 15 to page 3, line 3).

Present-day disc drive actuators are usually manufactured by casting or extrusion processes. The casting process involves placing a castable substance in a mold or form and allowing it to solidify. Extrusion consists of forcing a semisoft solid material, such as metal, through the orifice of a die to form a continuously formed piece in the desired shape of the actuator. Typically the resulting length of material is then cut into individual longitudinal sections, each corresponding to a single actuator. The placement of each cut thus defines the top of one actuator (on one side of the cut) and the bottom of another actuator (on the other side of the cut). Thus, the cross-sectional shape of the actuators, as viewed from above or below, is defined by the extrusion process. (Page 3, lines 4-13).

The processes of casting and extruding actuators inherently have profile tolerances that result in significant variation in arm resonance from actuator to actuator. (Page 3, lines 14-19).

II. THE PRESENT DISCLOSURE

FIG. 1 (Exhibit A) is a top view of a disc drive 100 in accordance with one embodiment of the present invention. Disc drive 100 includes a disc pack 106 mounted for rotation about a spindle 109. An actuator 116 is moveable relative to disc pack 106 about pivot shaft 120. Actuator 116 includes an E-block assembly 117, which includes a plurality of actuator arms 114. Each actuator arm 114 carries one or more flexure arms 112, which supports a data head 110 for reading information from and writing information to one of the discs 106. (Page 5, line 14 to page 6, line 17).

Figures 2 and 3 (Exhibit A) are perspective views of an actuator 116 according to an illustrative embodiment of the

present invention. Actuator 116 includes actuator body 124 having a pivot bore 126, which receives pivot shaft 120 (Figure 1). E-block 117 extends outwardly from actuator body 124 and includes multiple actuator arms 114. Each actuator arm 114 is adapted to couple to one or more flexure arms 112 (Figure 1). On the opposite side of the actuator body 124 from E-block 117 is a voice coil support 128, which supports a coil (not shown) that lies between a pair of permanent magnets, one above and one below. When drive current is applied to the coil, actuator 116 pivots about pivot shaft 120, thereby positioning data heads 110 (supported by arms 114) relative to disc pack 106. (page 6, line 24 to page 7, line 16).

For the purpose of the present application, surfaces 130, 132 and 134 (Figure 2), along with all other surfaces so oriented, are referred to as top surfaces, as these surfaces face upwardly when the drive 100 is disposed horizontally. Correspondingly, surfaces 136, 138 and 140 (Figure 3), as well as all other surfaces facing in the same direction, are referred to as bottom surfaces. All external surfaces of actuator 116 that are not substantially parallel to top surfaces 130, 132 and 134 and bottom surfaces 136, 138 and 140 are thus referred to as peripheral surfaces. In Figures 2 and 3, such peripheral surfaces include surfaces 142, 144, 146, 148, 150, 152, 154, 156, 158 and 160. (Page 6, line 17 to page 7, line4).

FIG. 4 (Exhibit A) is a flow chart representing a method of manufacturing a disc drive actuator 116 according to an illustrative embodiment of the present invention. At step 400, the actuator 116 is manufactured by extruding a length of solid material or casting a material in a mold such that a peripheral surface (142, 144, 146, 148, 150, 152, 154, 156, 158 or 160 in Figures 2 and 3) has a profile dimension that is greater than a desired final profile dimension. (Page 8, lines 5-18).

The length of material is then cut into longitudinal sections, at step 401, such that each longitudinal section corresponds to a single actuator 116. The length of extruded material is illustratively also further cut or machined, at step 402, to achieve the desired shape of the actuator. After actuator 116 is produced by extrusion or casting, bores through actuator 116 are drilled, at step 403. (Page 8, line 19 to page 9, line 2).

At step 404, the peripheral surface (surfaces 142, 144, 146, 148, 150, 152, 154, 156, 158 and 160 in Figures 2 and 3) of the actuator is machined to a desired final profile dimension. In one embodiment, substantially the entire periphery of actuator 116 is machined to the desired final profile dimension. The profile dimension is defined as the dimension perpendicular to the surface when viewed from above or below. (Page 9, lines 3-15).

Machining the periphery allows the surface to be manufactured to a lower tolerance than if the surface is simply extruded or molded without machining the surface. The precise profile dimension of the surface can be achieved with greater accuracy and greater certainty. Thus, when manufacturing a group of similar actuators, there will be less variance in the profile dimensions from one actuator to the next. This results in a reduced degree of variance in the resonance characteristics from one actuator to the next. (Page 9, line 16 to page 10, line 3).

FIG. 5 (Exhibit A) is a top view of actuator 116. Dashed line 500 shows the profile dimension of the peripheral surface after the extrusion or casting. Solid line 502 shows the desired profile of the peripheral surface. Profile dimension 502 is achieved by machining the surface. (Page 10, lines 4-23).

According to an illustrative embodiment of the present invention, a machined surface is achieved by advancing machining tool 504 about the periphery of actuator 116 while maintaining contact between the machining tool and the peripheral surface of

the actuator. Machining tool 504 is advanced about the periphery of the actuator along a predetermined path designated by dashed line 506. In one embodiment, machining tool 504 is an end mill, which has a rotating shank with cutting teeth at the end and spiral blades on the peripheral surface. (Page 10, line 24 to page 11, line 17).

GROUND OF REJECTION TO BE REVIEWED ON APPEAL

Whether claim 13 meets the requirements of novelty under 35 U.S.C. § 102(e), and is thus patentable over Wood et al. U.S. Patent No. 6,038,105 (Exhibit B).

Whether claims 17-18 meet the requirements of non-obviousness under 35 U.S.C. § 103(a), and are thus patentable over Wood et al. (Exhibit B) in view of Brar et al. U.S. Patent 5,156,919 (Exhibit C).

ARGUMENT

I. THE REJECTION OF CLAIM 13 SHOULD BE REVERSED

Claim 13 was rejected under §102(e) as being anticipated by Wood et al., U.S. Patent No. 6,038,105 (Exhibit B).

Claim 13 is directed to a disc drive comprising "an actuator with a machined external peripheral surface extending along an entire periphery of the actuator and comprising a desired profile dimension entirely defined by the machined external peripheral surface."

A. The Office Action Mischaracterizes Wood et al.

With regard to claim 13, the Office Action inaccurately states that, "Wood et al shows an actuator 115, with machined external peripheral surface extending along an entire periphery of the actuator and including a desired profile dimension entirely defined by the machined external peripheral surface (Fig. 2; column 4, lines 53-54)."

Wood et al. does not disclose an actuator with a machined external peripheral surface extending along an entire periphery of the actuator or a desired profile dimension entirely

defined by the machined external peripheral surface, as recited in claim 13.

The citation referred to by the Examiner simply states that the "E-block 115 is typically precision machined from a lightweight material such as aluminum or magnesium to form central bore 138 as well as the plurality of actuator arms 116."

This statement simply identifies a typical structure of an E-block. As described on page 3, lines 4-19 of the present application, actuators are usually manufactured by casting or extrusion processes. The casting process involves placing a castable substance in a mold or form and allowing it to solidify. Extrusion involves forcing a semisoft solid material, such as metal, through the orifice of a die to form a continuously formed piece in the desired shape of the actuator. Typically the resulting length of material is then cut into individual longitudinal sections, each corresponding to a single actuator. The placement of each cut thus defines the top of one actuator (on one side of the cut) and the bottom of another actuator (on the other side of the cut). Thus, the cross-sectional shape of the actuators, as viewed from above or below, is defined by the extrusion process.

As further discussed on page 8, line 20-25 of the present application, "the length of extruded material is illustratively also further cut or machined, at step 402, to achieve the desired shape of the actuator, as is known in the art. For example, extraneous material above and below voice coil support 128 is cut or machined away. Similarly, material above, below and between actuator arms 114 is cut or machined away." (Emphasis added).

The cited sentence in Wood et al. simply reflects this traditional method of making an E-block, whereby the part is extruded or cast and then machined to define elements of the E-block. However, the profile dimension, when viewed from above or

below (the external peripheral surface) remains defined by the casting or extrusion process. This is what a person of ordinary skill in the art would understand when reviewing the Wood et al. patent.

Nowhere does Wood et al. teach or suggest that E-block has a machined external peripheral surface extending along an entire periphery of the actuator and comprising a desired profile dimension entirely defined by the machined external peripheral surface. Therefore, the above-statement in the Office Action regarding the Wood et al. disclosure is not supported by the reference and is inaccurate.

Since Wood et al. do not teach or suggest an actuator comprising a machined external peripheral surface that extends along an entire periphery of the actuator and comprising a desired profile dimension entirely defined by the machined external peripheral surface, Applicants respectfully request that the rejection of claim 13 under §102(e) be reversed.

2. Withdrawal of "Product by Process" Assertion

Applicant notes that with the present Office Action, the Examiner has withdrawn a previous assertion that the term "machined" is a product by process limitation.

Claim 13 requires the actuator to have a "machined external peripheral surface." As described in greater detail in Applicant's previous responses, Appeal Briefs and accompanying Declaration of David D. Koester, this phrase is a structural element within the context of the claim since a "machined external peripheral surface" can clearly be identified by inspection of the surface and its properties.

II. THE REJECTION OF CLAIMS 17 AND 18 UNDER §103(a) SHOULD BE REVERSED

Claims 17 and 18 were rejected under §103(a) as being unpatentable over Wood et al. (Exhibit B) in view of Brar et al., U.S. Patent No. 5,156,919 (Exhibit C).

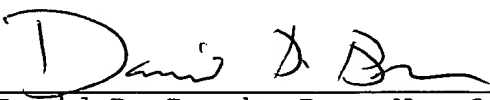
Claims 17 and 18 are dependent claims that depend from independent claim 13. Claims 17 and 18 specify tolerances of the machined external peripheral surface relative to the desired profile dimension.

The Office Action acknowledges that Wood et al. is silent on the tolerance of the dimension of the surface but suggests this tolerance would be obvious in view of Brar et al. However, as discussed above, Wood et al. fail to teach or suggest a machined external surface extending along an entire periphery of an actuator. Therefore even if the teachings of Brar et al. were combined with those of Wood et al., the resulting combination would still fail to teach or suggest all of the elements of dependent claims 17 and 18, including the elements of independent claim 13. Accordingly, Applicants respectfully request that the rejection of claims 17 and 18 under §103(a) be reversed.

CONCLUSION

Applicants respectfully request that the Board reverse the Examiner and find that claims 13 and 17-18 are in condition for allowance.

WESTMAN, CHAMPLIN & KELLY, P.A.

By: 
David D. Brush, Reg. No. 34,557
Suite 1600 - International Centre
900 Second Avenue South
Minneapolis, Minnesota 55402-3319
Phone: (612) 334-3222 Fax: (612) 334-3312

DDB:

APPENDIX 1

13. (Amended) A disc drive comprising an actuator with a machined external peripheral surface extending along an entire periphery of the actuator and comprising a desired profile dimension entirely defined by the machined external peripheral surface.

17. (Amended) The disc drive of claim 13 wherein the machined external peripheral surface of the actuator has a tolerance of less than 0.010 inches relative to the desired profile dimension.

18. (Amended) The disc drive of claim 13 wherein the machined external peripheral surface of the actuator has a tolerance of 0.005 inches or less relative to the desired profile dimension.

19. (Amended) A disc drive comprising:
a disc rotatable about a central axis; and
actuator means for supporting and actuating a transducer relative to the disc and having a machined external peripheral surface with a desired profile dimension, which is within a tolerance of less than 0.010 inches relative to the desired profile dimension, that is defined for limiting variations in resonance characteristics of the actuator means.

20. The disc drive of claim 19 wherein the machined external peripheral surface extends along an entire

periphery of the actuator means such that the desired profile dimension is defined entirely by the machined peripheral surface.

21. The disc drive of claim 19 wherein the machined external peripheral surface of the actuator has a tolerance of 0.005 inches or less relative to the desired profile dimension.

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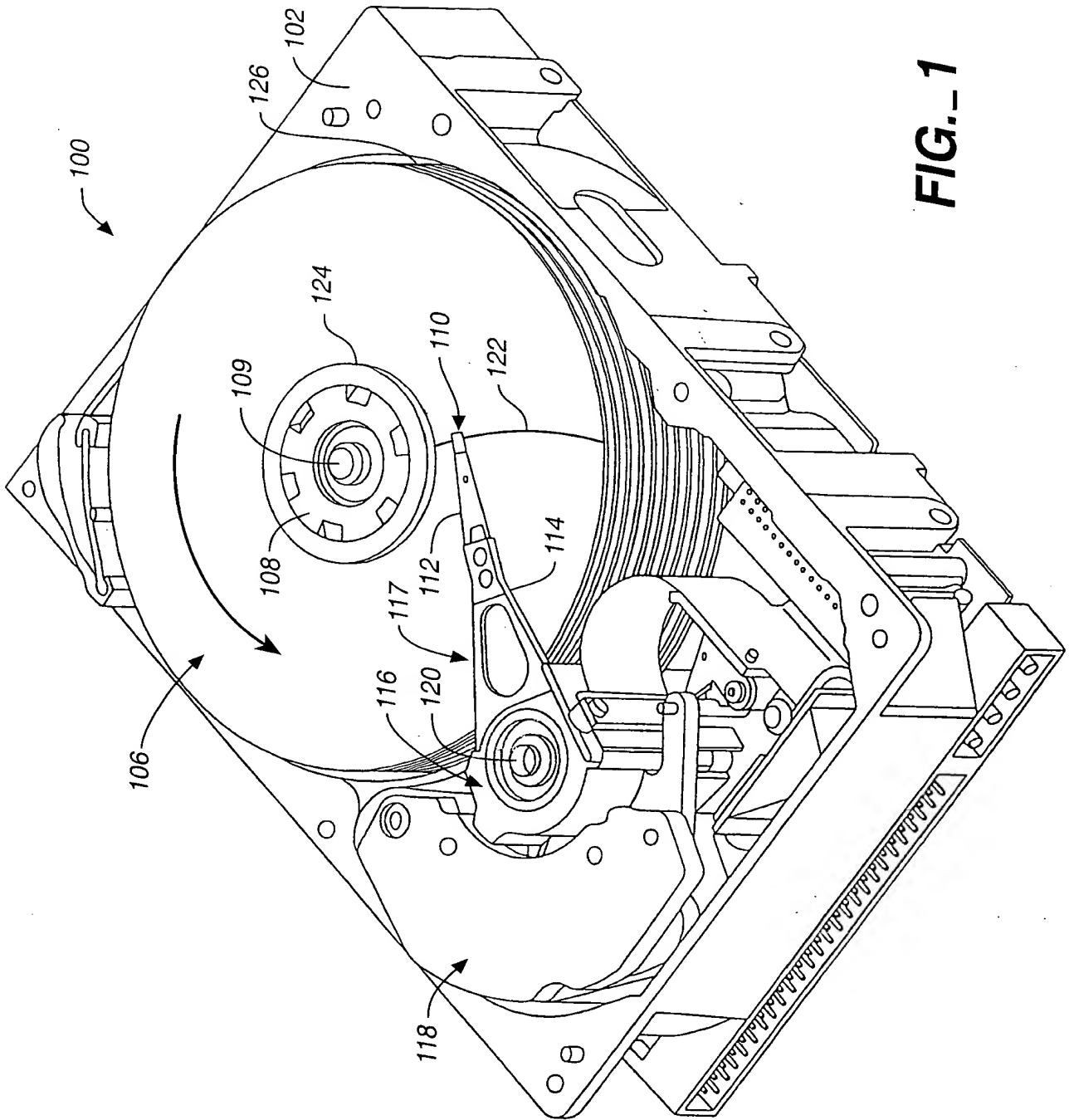
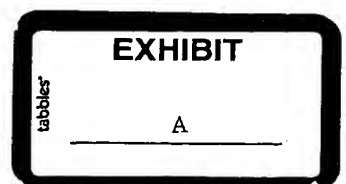
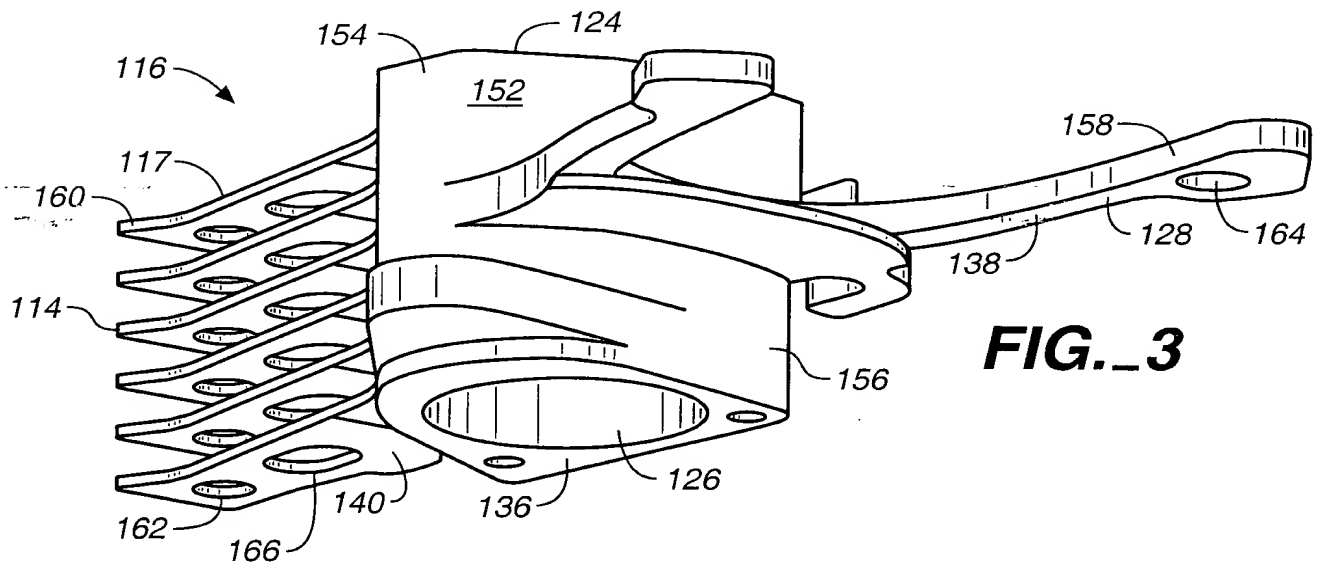
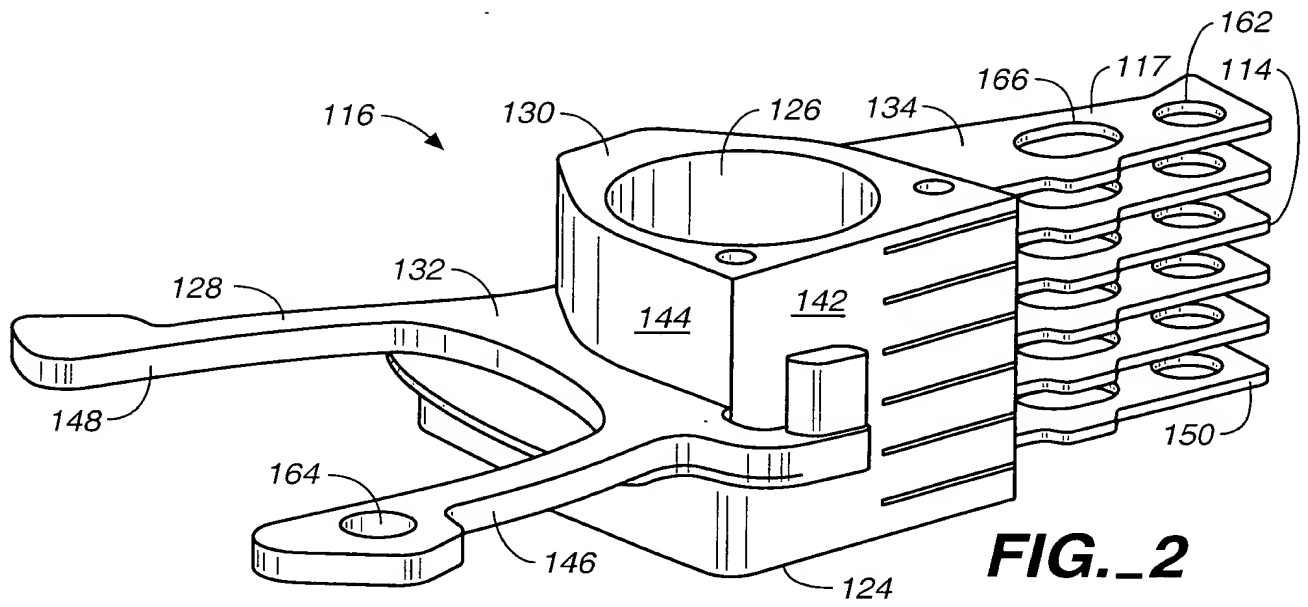
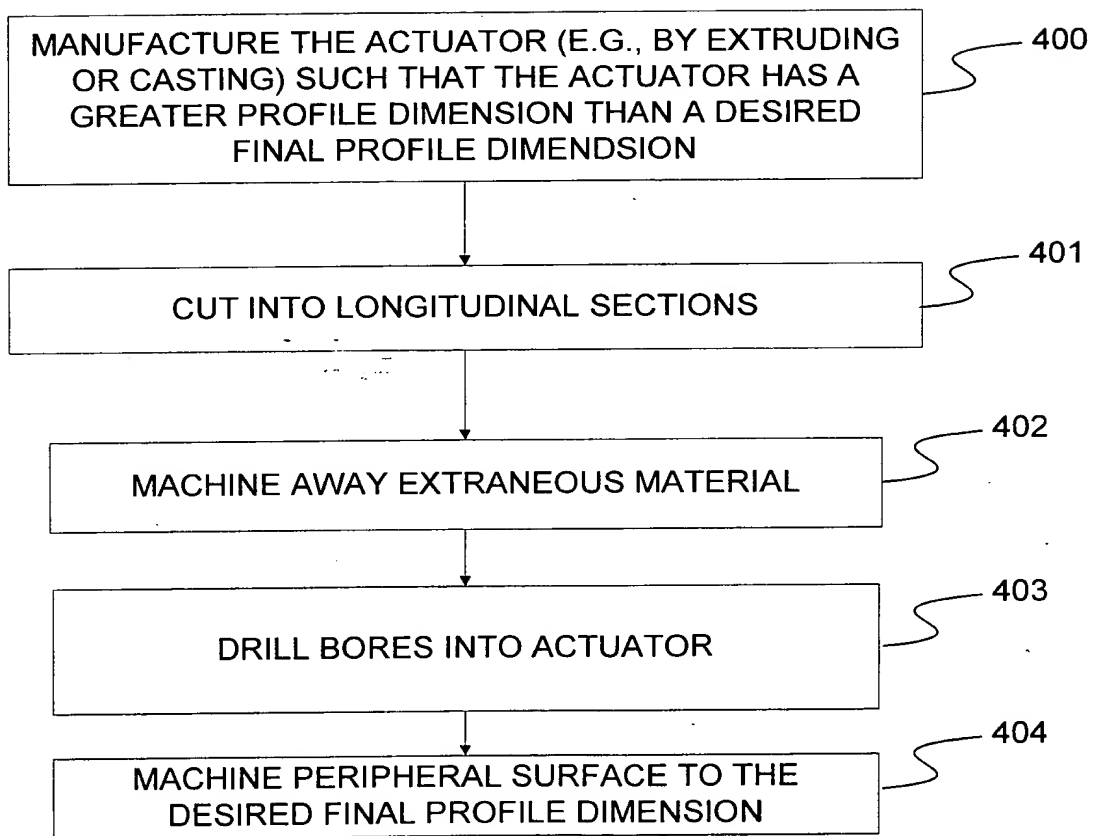
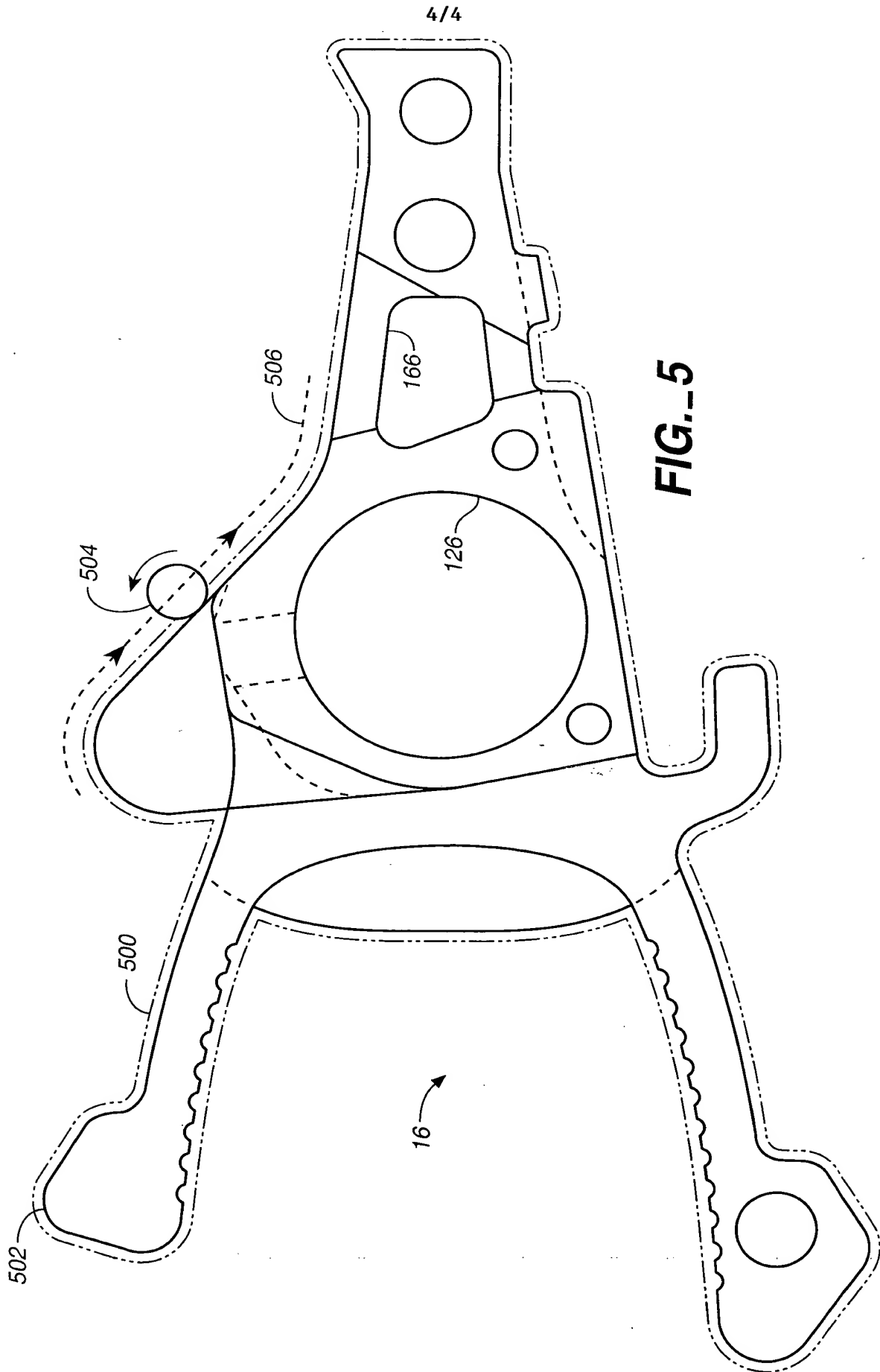


FIG. 1





**FIG._4**





US006038105A

United States Patent [19][11] **Patent Number:** **6,038,105****Wood et al.**[45] **Date of Patent:** **Mar. 14, 2000**[54] **TEMPERATURE-COMPENSATED ROTARY ACTUATOR CARTRIDGE BEARING STABILIZER**[75] Inventors: **Roy L. Wood, Yukon; John D. Stricklin, Oklahoma City; Nigel F. Misso, Bethany, all of Okla.**[73] Assignee: **Seagate Technology, Inc.**[21] Appl. No.: **09/104,616**[22] Filed: **Jun. 25, 1998****Related U.S. Application Data**

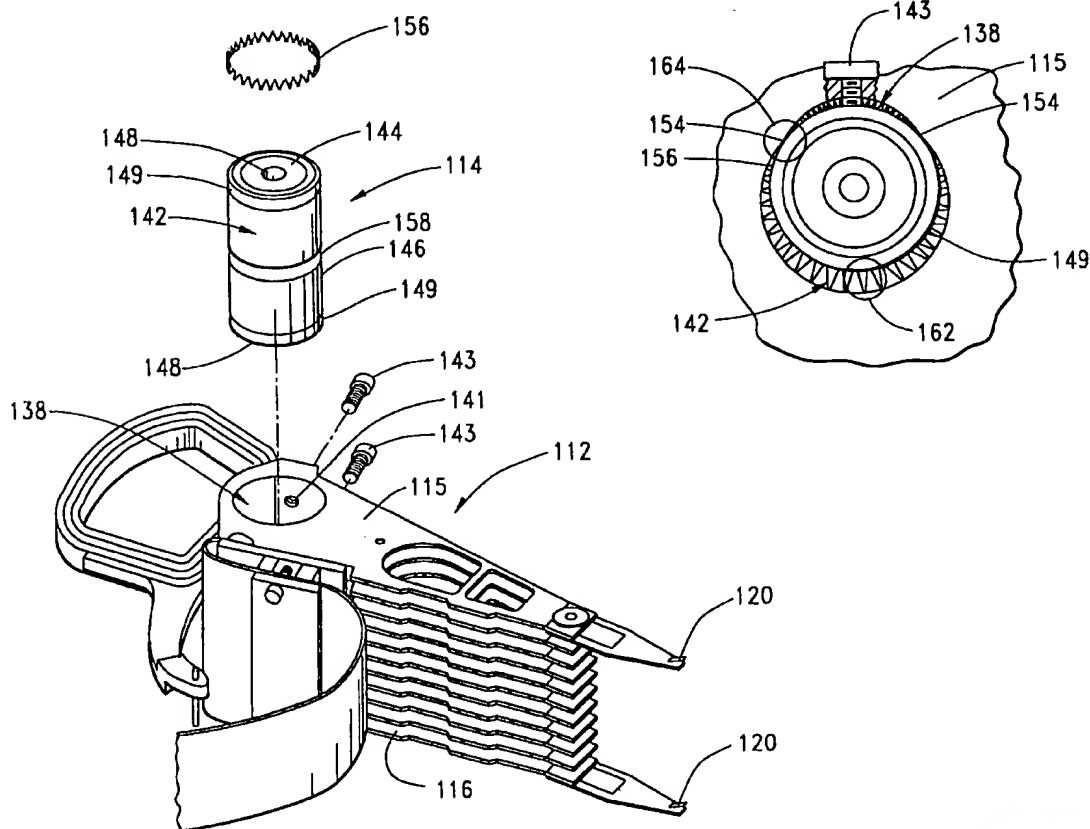
[60] Provisional application No. 60/067,694, Dec. 1, 1997, abandoned.

[51] Int. Cl.⁷ **G11B 5/55**[52] U.S. Cl. **360/106**

[58] Field of Search 360/106; 384/518, 384/519, 535, 536

[56] **References Cited****U.S. PATENT DOCUMENTS**5,570,250 10/1996 Casey 360/106
5,666,242 9/1997 Edwards et al. 360/1065,675,456 10/1997 Myers 360/106
5,731,934 3/1998 Brooks et al. 380/106
5,818,665 10/1998 Malagrino, Jr. et al. 360/106
5,894,382 4/1999 Hyde 360/106
5,914,837 6/1999 Edwards et al. 360/106
5,930,071 7/1999 Back 360/97.01**Primary Examiner**—Jefferson Evans**Attorney, Agent, or Firm**—Shawn B. Dempster; Edwards P. Heller, III; Jonathan E. Olson[57] **ABSTRACT**

An improved attachment of an actuator E-block of an actuator assembly to a pivot bearing assembly for a disc drive, the E-block having a central bore having a pair of alignment edges to pressingly engage a cartridge bearing of the pivot shaft bearing assembly, and the cartridge bearing supporting a canted coil spring within a peripheral groove so that the spring is interposed between the cartridge bearing and the E-block within the E-block bore. One or more fasteners extend through the wall of the E-block adjacent the alignment edges to pressingly engage the cartridge bearing against the alignment edges, the canted coil spring filling the clearance gap between the cartridge bearing and the E-block bore to provide a resilient support to the E-block.

19 Claims, 4 Drawing Sheets**EXHIBIT****B**

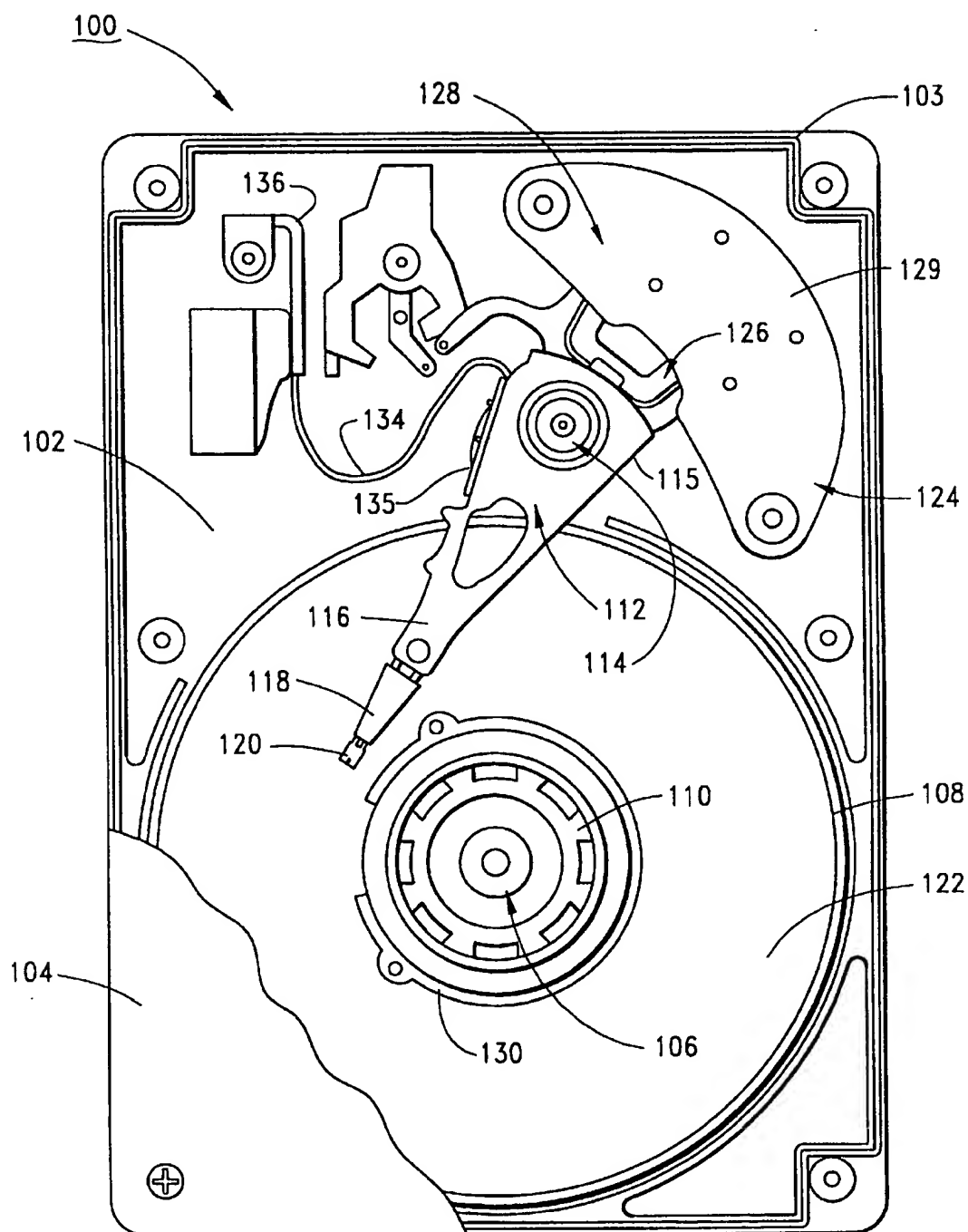


FIG. 1

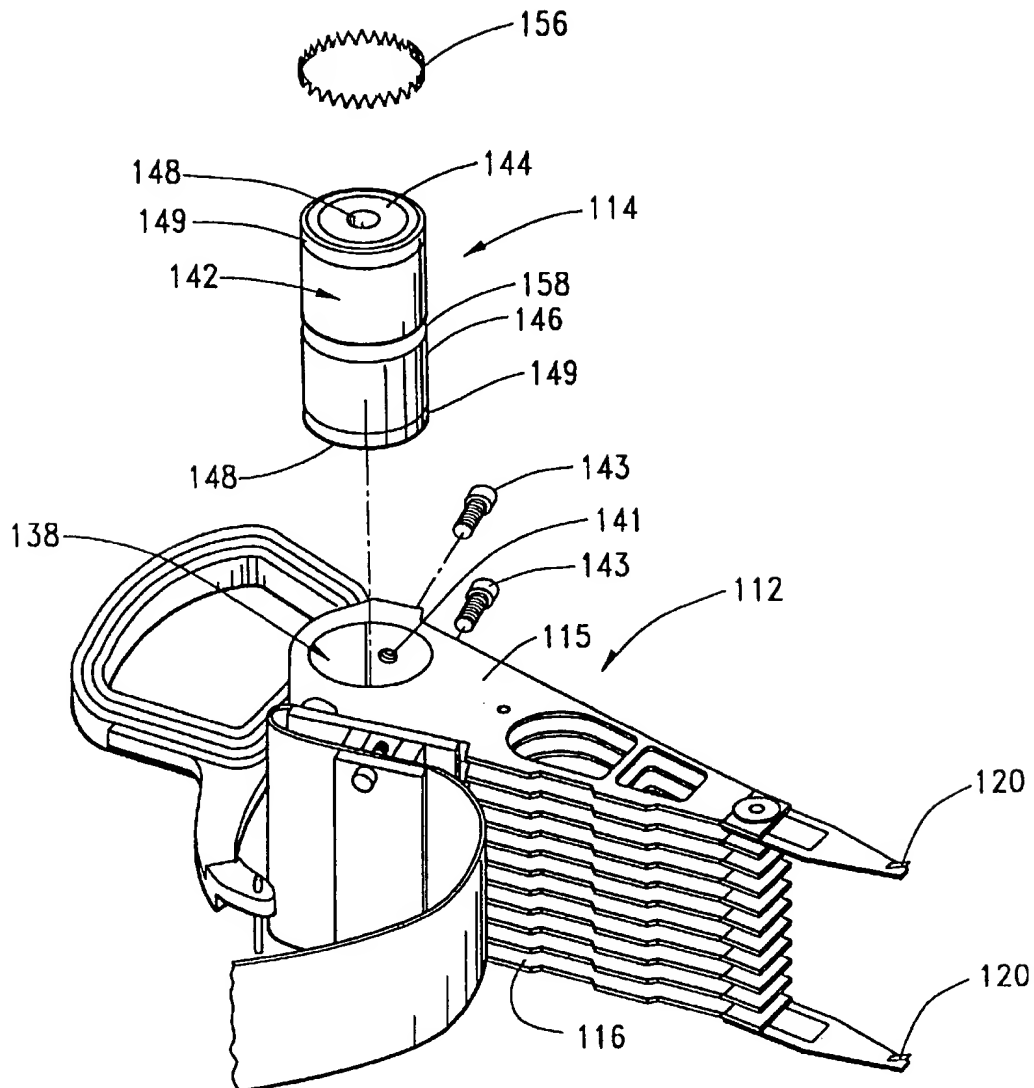
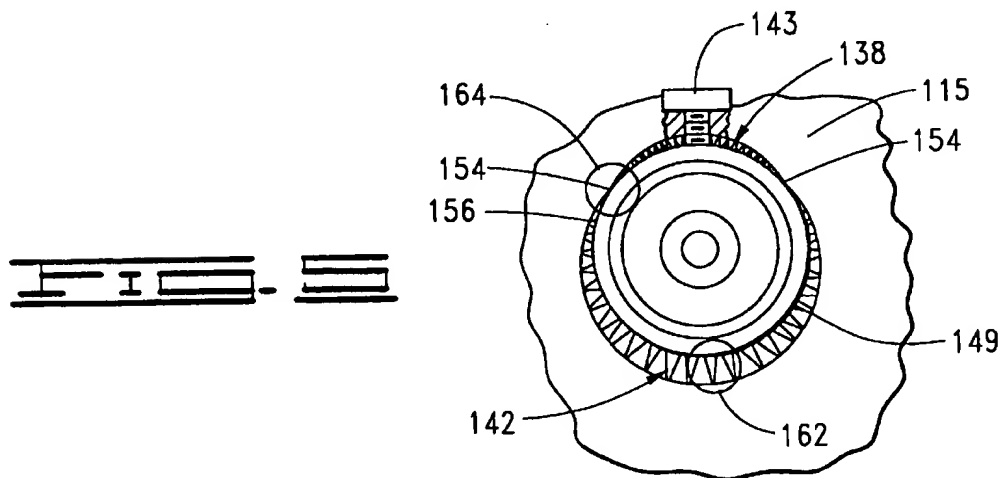
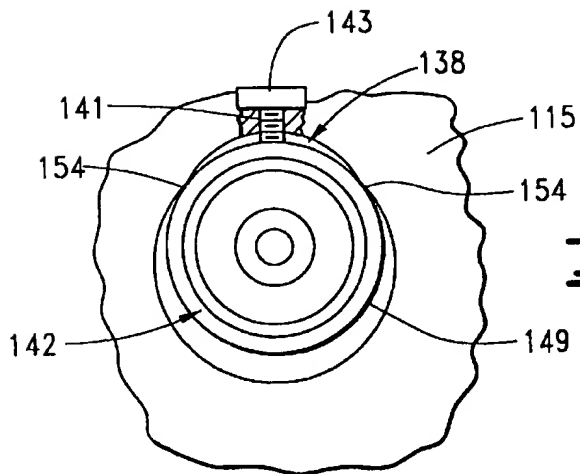
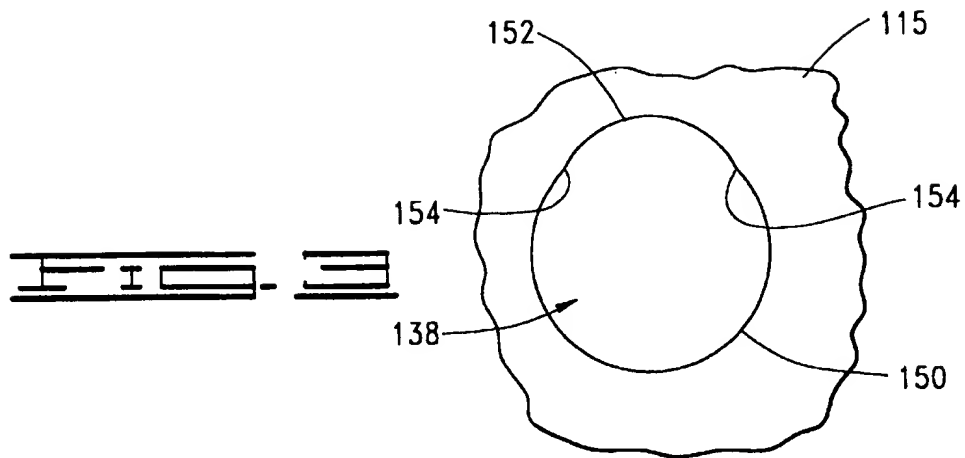


FIG. 2



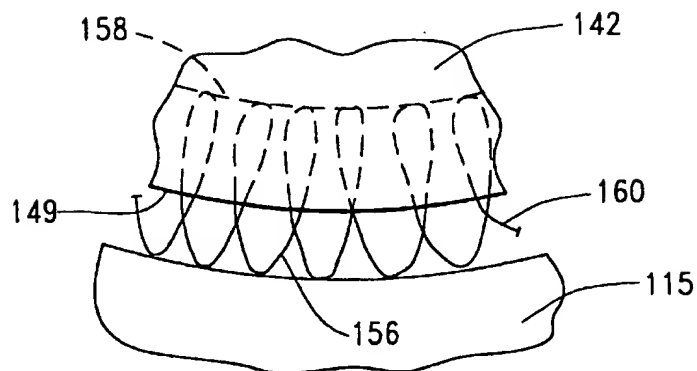


FIG. 1

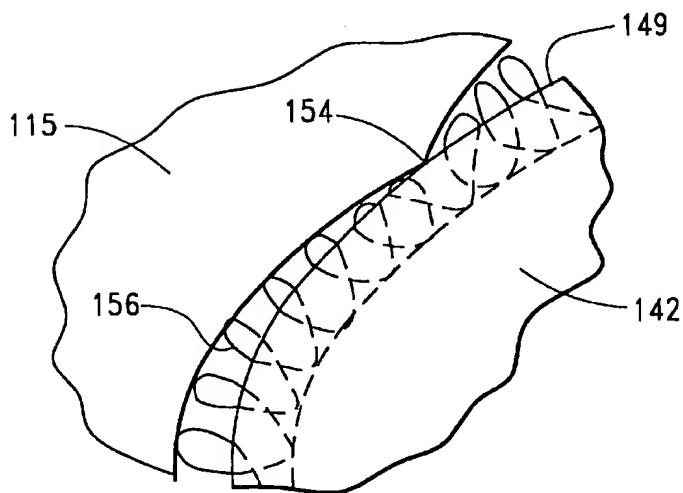
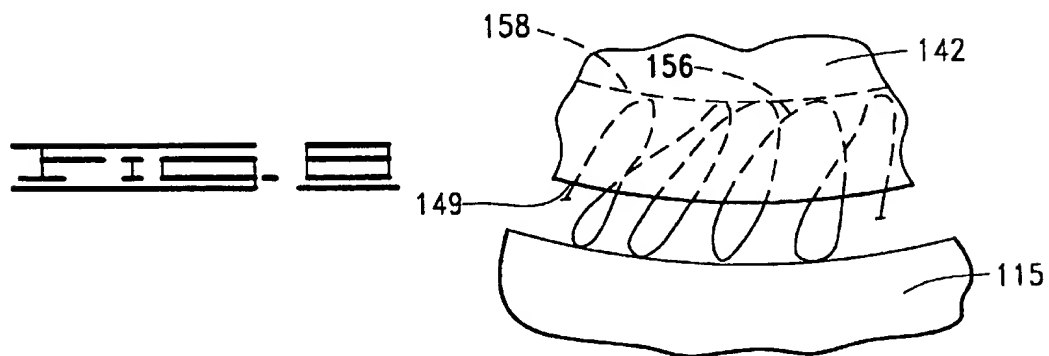


FIG. 2



1

TEMPERATURE-COMPENSATED ROTARY ACTUATOR CARTRIDGE BEARING STABILIZER

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/067,694, entitled CANTED COIL SPRING BEARING CARTRIDGE MOUNTING, filed Dec. 1, 1997.

FIELD OF THE INVENTION

The present invention relates generally to the field of disc drive data storage devices, and more particularly but not by way of limitation, to an improved apparatus for attachment of a cartridge bearing assembly to an actuator arm assembly.

BACKGROUND OF THE INVENTION

Modern disc drives are commonly used in a multitude of computer environments, ranging from super computers to notebook computers, to store large amounts of data in a form that is readily available to a user. Typically, a disc drive has one or more magnetic discs that are rotated by a spindle motor at a constant high speed. Each disc has a data storage surface divided into a series of generally concentric data tracks that are radially spaced across a band having an inner diameter and an outer diameter. The data is stored within the data tracks on the disc surfaces in the form of magnetic flux transitions. The flux transitions are induced by an array of read/write heads. Typically, each data track is divided into a number of gap sectors where data is stored in fixed size data blocks.

The read/write head includes an interactive element such as a magnetic transducer. The interactive element senses the magnetic transitions on a selected data track to read the data stored on the track. Alternatively, the interactive element transmits an electrical signal that induces magnetic transitions on the selected data track to write data to the track.

Each of the read/write heads is mounted to a rotary actuator arm and is selectively positioned by the actuator arm over a pre-selected data track of the disc to either read data from or write data to the data track. The read/write head includes a slider assembly having an air bearing surface that, in response to air currents caused by rotation of the disc, causes the head to fly adjacent to the disc surface with a desired gap separating the read/write head and the corresponding disc.

Typically, multiple center-open discs and spacer rings are alternately stacked on a spindle motor hub. The hub, defining the core of the stack, serves to align the discs and spacer rings around a common axis. Collectively the discs, spacer rings and spindle motor hub define a disc pack assembly. The surfaces of the stacked discs are accessed by the read/write heads which are mounted on a complementary stack of actuator arms which form a part of an actuator assembly. The actuator assembly generally includes head wires which conduct electrical signals from the read/write heads to a flex circuit which, in turn, conducts the electrical signals to a flex circuit connector mounted to a disc drive base deck.

When the disc drive is not in use, the read/write heads are parked in a position separate from the data storage surfaces of the discs. Typically, a landing zone is provided on each of the disc surfaces where the read/write heads are positioned before the rotational velocity of the spinning discs decreases below a threshold velocity which sustains the air bearing.

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The landing zones are generally located near the inner diameter of the discs.

Generally, the actuator assembly has an actuator body that pivots about a pivot mechanism disposed in a medial portion thereof. A motor, such as a voice coil motor, selectively positions a proximal end of the actuator body. This positioning of the proximal end in cooperation with the pivot mechanism causes a distal end of the actuator body, which supports the read/write heads, to move radially across the face of the discs. The function of the pivot mechanism is crucial in meeting performance requirements associated with the positioning of the actuator assembly. A typical pivot mechanism has two ball bearings with a stationary shaft attached to an inner race and a sleeve attached to an outer race. The sleeve is also attached to a bore in the actuator body. The stationary shaft typically is attached to the base deck and the top cover of the disc drive.

A well known problem occurs as the result of thermal cycling which alters the compressive force that retains the sleeve in the actuator body. This is especially true when many or all the components of the cartridge bearing are made of steel in order to increase the strength and wear resistance. The actuator body is typically made of aluminum or magnesium to minimize the weight and inertia. The different materials provides a differential thermal expansion, that is, the actuator and cartridge bearing expand and contract at different rates and to different extents in a given temperature range.

A solution to the differential thermal expansion problem is to provide a resilient mounting of the actuator body to the cartridge bearing, so that relative thermal expansion and contraction can occur without affecting the preload or stress on the cartridge bearing. Such a solution involves providing an eccentric bore in the actuator body so that the cartridge bearing contacts the actuator body along a minimum contact surface, the rest of the cartridge bearing thus unencumbered and free to expand and contract during thermal cycling. The primary drawback to such a solution is that by minimizing the support of the actuator body makes the actuator assembly susceptible to undesired deflection which results in positional overshooting during data seek routines due to the torsion on the actuator body.

There is a long felt need in the industry for an improved apparatus for attaching the actuator body to the cartridge bearing, the improved apparatus combining the performance benefits of the rigid attachment, which minimizes overshoot conditions, with the performance benefits of the resilient attachment, which allows for differential thermal expansion of mating components.

SUMMARY OF THE INVENTION

The present invention provides an improved attachment of an actuator E-block of an actuator assembly to a cartridge bearing of a pivot shaft bearing assembly in a disc drive.

The actuator assembly of the present invention has an E-block member which has a central bore which is sized to be supported on the outer housing of a cartridge bearing assembly, the central bore defining a pair of opposed alignment edges which operably engage the cartridge bearing housing when the E-block is supported thereon.

One or more fasteners extend through a wall of the E-block to engage the cartridge bearing housing to apply a tensile load which pressingly engages the cartridge bearing housing against the alignment edges, thereby establishing a line contact therebetween the cartridge bearing and the E-block.

The cartridge bearing housing has a peripheral groove in a medial portion thereof which receivingly supports a canted coil spring. The canted coil spring thereby extends beyond the medial diameter of the cartridge bearing housing and fills a clearance gap between the housing and the E-block within the E-block bore. The individual upstanding coils of the canted coil spring pressingly engage both the housing and the E-block so as to extend support by the cartridge bearing assembly to the E-block within the periphery of the E-block bore. The coils of the canted coil spring vary in angular attitude as the clearance between the housing and the E-block varies, so as to provide a continuous and resilient support to the E-block.

The advantages and features of the present invention will be apparent from the following description when read in conjunction with the drawings and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of a disc drive constructed in accordance with the present invention.

FIG. 2 is a perspective view of the actuator assembly and the pivot shaft bearing assembly of the disc drive of FIG. 1.

FIG. 3 is a top view of the eccentric bore of the actuator assembly of FIG. 2.

FIG. 4 is a top view of a portion of the actuator assembly of FIG. 2, showing the prior art construction of attaching the E-block to the cartridge bearing.

FIG. 5 is a top view of a portion of the actuator assembly of FIG. 2, showing the construction of attaching the E-block to the cartridge bearing in accordance with a preferred embodiment of the present invention.

FIG. 6 is a detail view of a portion of the cartridge bearing and E-block of FIG. 5, showing the canted coil spring in an area where the clearance gap between the cartridge bearing and the E-block is substantially constant.

FIG. 7 is a detail view of a portion of the cartridge bearing and E-block of FIG. 5, showing the canted coil spring in an area where the clearance gap between the cartridge bearing and the E-block varies.

FIG. 8 is a detail view of the portion of the cartridge bearing and E-block of FIG. 6, showing the change in attitude of the spiral wound coils of the canted coil spring in response to a reduction in the clearance between the cartridge bearing and the E-block.

DETAILED DESCRIPTION

Referring to the drawings in general, and more particularly to FIG. 1, shown therein is a top view of a disc drive 100 constructed in accordance with a preferred embodiment of the present invention. The disc drive 100 includes a base deck 102 to which various disc drive components are mounted, and a top cover 104, which together with the base deck 102 and a perimeter gasket 103 provide a sealed internal environment for the disc drive 100. The top cover 104 is shown in a partial cut-away fashion to expose selected components of interest. It will be understood that numerous details of construction of the disc drive 100 are not included in the following description, as such, they are well known to those skilled in the art and are believed to be unnecessary for the purpose of describing the present invention.

Mounted to the base deck 102 is a spindle motor 106 to which a plurality of discs 108 are mounted and secured by a clamp ring 110 for rotation at a constant high speed. Adjacent the discs 108 is an actuator assembly 112 which pivots about a pivot shaft bearing assembly 114, sometimes

referred to as a pivot mechanism, in a rotary fashion. The actuator assembly 112 includes an E-block 115 that is supported by the pivot shaft bearing assembly 114. The E-block 115 has actuator arms 116 (only one shown) that support load arm assemblies 118. The load arm assemblies 118 in turn support read/write heads 120, with each of the heads 120 adjacent a surface of one of the discs 108. As mentioned hereinabove, each of the discs 108 has a data recording surface 122 divided into concentric circular data tracks (not shown), and the heads 120 are positionably located adjacent data tracks to read data from, or write data to, the tracks.

The actuator assembly 112 is controllably positioned by a voice coil motor assembly (VCM) 124, comprising an actuator coil 126 immersed in the magnetic field generated by a magnet assembly 128. A magnetically permeable flux path, such as a steel plate 129, is mounted above the actuator coil 126 to complete the magnetic circuit of the VCM 124. When controlled current is passed through the actuator coil 126, an electromagnetic field is set up which interacts with the magnetic circuit of the VCM 124 to cause the actuator coil 126 to move relative to the magnet assembly 128 in accordance with the well-known Lorentz relationship. As the actuator coil 126 moves, the actuator assembly 112 pivots about the pivot shaft bearing assembly 114, causing the actuator arms 116 to move the heads 120 adjacent to, and across, the discs 108. Located near the inner clamp ring 110 are parking surfaces 130, the parking surfaces 130 being non-data surfaces that are designated areas where the heads 120 come to rest when the disc drive 100 becomes non-operational, the provision of the parking surfaces 130 preventing the heads 120 from damaging any data storage locations.

To provide the requisite electrical conduction paths between the heads 120 and disc drive read/write circuitry (not shown), head wires (not separately shown) are routed on the actuator assembly 112 from the heads 120, along the load arm assemblies 118 and the actuator arms 116, to a flex circuit 134. The head wires are secured by way of a suitable soldering process to corresponding pads of a printed circuit board (PCB) 135 of the flex circuit 134. In turn, the flex circuit 134 is connected to a flex circuit bracket 136 in a conventional manner, which, in turn, is connected through the base deck 102 to a disc drive PCB (not shown) mounted to the underside of the base deck 102. The disc drive PCB provides the disc drive read/write circuitry which controls the operation of the heads 120, as well as other interface and control circuitry for the disc drive 100.

Turning now to FIG. 2, shown therein is a perspective, partially exploded view of the actuator assembly 112 and the pivot shaft bearing assembly 114. The pivot shaft bearing assembly 114 is shown removed from a central bore 138 that is formed in the E-block 115. The E-block 115 is typically precision machined from a lightweight material such as aluminum or magnesium to form the central bore 138 as well as the plurality of actuator arms 116. The E-block 115 furthermore has one or more openings 141 for the passage of a fastener 143 as described below to secure the pivot shaft bearing assembly 114.

The pivot shaft bearing assembly 114 has a cartridge bearing 142 having a stationary shaft 144 attached to an inner race of an internal set of ball bearings (not shown), and having a housing 146 attached to an outer race of the ball bearings. The stationary shaft 144 has openings 148 on both ends thereof for receiving disposition of a fastener (not shown) for attachment of the stationary shaft 144 to the base deck 102 and to the top cover 104. In this manner it will be

understood that the stationary shaft 144 is rigidly supported by the base deck 102 and the top cover 104 and the housing 146 rotates thereabout in rotational support and positioning of the actuator assembly 112.

The cartridge bearing 142 has a pair of shoulder portions 149 at the top and bottom ends of the housing 146, the shoulder portions 149 forming surfaces having a greater diameter than the medial portion of the housing 146 therebetween. The bore 138 of the E-block 115 forms an eccentric opening into which the cylindrical cartridge bearing 142 is disposed. FIG. 3 is a top view of a portion of the E-block 115 showing the bore 138 which is formed by the intersection of a primary arcuate opening 150 and a secondary arcuate opening 152. The intersection of the openings 150, 152 forms an alignment edge 154.

FIG. 4 is a top view of a portion of the E-block 115 showing the bore 138 of FIG. 3 and with a cartridge bearing 142 installed therein. It will be noted that one or more fasteners 143 pass through the corresponding openings 141 in the E-block 115 to engage the housing 146 of the cartridge bearing 142. In the embodiment shown in FIG. 2 and FIGS. 4 and 5, the fastener 143 is a threaded screw which clearly passes through the opening 141 in the E-block 115 to threadingly engage threaded apertures (not shown) in the housing 146 of the cartridge bearing 142. In this manner, tightening of the fastener 143 imparts a tensile force on the fastener 143 and urges the cartridge bearing 142 into pressing engagement with the alignment edges 154. The shoulder portions 149 at the top and bottom extents of the cartridge bearing 142, being of a greater diameter than the medial portion of the housing 146, provide the contact surfaces between the cartridge bearing 142 and the alignment edges 154.

FIG. 4 thus illustrates the conventional manner in which the cartridge bearing 142 is attached to the E-block 115. With the shoulder portions 149 of the cartridge bearing 142 making line contact at the alignment edges 154 of the bore 138, a minimal surface contact is provided between the cartridge bearing 142 and the E-block 115.

A limitation of the conventional configuration, however, is that the resilient mounting of the cartridge bearing 142 within the E-block 115, that is the line contact therebetween and the clearance gap elsewhere, permits deflection of the E-block 115 relative to the cartridge bearing 142 in response to the torsion produced during seek operations of the actuator assembly 112 as the actuator assembly 112 seeks a selected data track. The deflection can be significant enough to create an overshoot condition requiring iterative repositioning of the actuator assembly 112 and thus increasing the seek time response.

FIG. 5 shows the cartridge bearing 142 attached to the E-block 115 in a manner in accordance with the present invention, wherein the pivot shaft bearing assembly includes a canted coil spring 156 interposed between the cartridge bearing 142 and the E-block 115. The canted coil spring 156 provides a stabilizing support of the E-block 115 to reduce the amount of deflection of the E-block 115 relative to the cartridge bearing 142 during data track seek operations of the actuator assembly 112.

The canted coil spring 156 is a continuous-loop type having the terminal ends thereof joined together, such as by welding. Such a canted coil spring 156 suitable for use in the present invention is available from Ball Seal Engineering Company, Inc., of Santa Ana, Calif. FIG. 2 shows the medial portion of the housing 146 has a retaining groove 158 into which the canted coil spring 156 is receivingly disposed.

A number of advantages are achieved by the use of the canted coil spring 156 as opposed to commonly known methods of securing the cartridge bearing 142 to the E-block 115 such as by the use of adhesives or by press fitting the mating components. One such advantage is that the canted coil spring 156 extends a uniform support from the cartridge bearing 142 due to the characteristic nature of the canted coil spring 156 wherein each coil independently supports the E-block 115. It will be noted from the following that the individual coils 160 of the canted coil spring 156 act as independent columnar supports which assume varying slopes in response to the clearance between the cartridge bearing 142 and the E-block 115.

FIG. 6 is a schematic detail of a portion of the canted coil spring 156 of FIG. 5 in the section designated by the numeral 162. In this section the clearance between the E-block 115 and the cartridge bearing 142 is substantially constant. It will be noted that the coils 160 of the canted coil spring 156 are substantially parallel and have an attitude slightly less than perpendicular to the cartridge bearing 142 and the E-block 115.

FIG. 7, however, is a schematic detail of a portion of the canted coil spring 156 in the section designated by the numeral 164, illustrating the manner in which the individual coils 160 change in sloping attitude where the clearance between the cartridge bearing 142 and the E-block 115 varies. At the contact point of the shoulder portion 149 and the alignment edge 154 the coils 160 approach a tangential relationship to the cartridge bearing 142 as the clearance between the cartridge bearing 142 and the E-block 115 decreases. Coils 160 farther away from the alignment edge 154 are ever increasingly erect and approach the near-perpendicular attitude of the coils 160 of FIG. 6. In this manner the individual coils 160 support the cartridge bearing 142 evenly about the circumference thereof. This support dampens the resonant response and deflection of the E-block 115 relative to the cartridge bearing 142 during data seek operations, thereby reducing the likelihood of an overshoot condition.

Another advantage to the use of the canted coil spring 156 is that resilient support is provided within the entire operating temperature range of the disc drive 100. Typically the E-block 115 is manufactured of a lightweight material such as aluminum or magnesium, while the housing 146 and other internal components of the cartridge bearing 142 are produced from steel to provide the necessary strength and wear characteristics. The disc drive 100 is expected to operate at least within a -40°C. and $+70^{\circ}\text{C.}$ temperature range, which creates a significant change in the clearance between the cartridge bearing 142 and the E-block 115. The change in clearance is the result of differential thermal expansion of the dissimilar materials. A rigidly mounted cartridge bearing 142, such as one adhered or press-fitted into the E-block 115, is constrained such that differential thermal expansion imparts distortion and residual stress into the cartridge bearing 142. This produces increased resonance and frictional resistance in the actuator assembly 112.

In the present invention, however, a change in the clearance resulting from differential thermal expansion is accommodated by the canted coil spring 156 which conforms to the clearance by varying the angular attitude of the coils 160. FIG. 8 is a schematic representation of the view of FIG. 6 at a different temperature, such that by differential thermal expansion the clearance has decreased between the cartridge bearing 142 and the E-block 115. It will be noted that the angular attitude of the coils 160 of the canted coil spring 156 has decreased from that of the attitude in FIG. 6, in response

to the decreased clearance. In this manner the canted coil spring 156 provides a resilient support of the cartridge bearing 142 over the full range of operating temperatures, by the canted coil spring 156 compensating for the variable clearance a constant support is provided thereby without distorting the cartridge bearing 142.

The present invention provides an improved actuator assembly for a disc drive (such as 100), the actuator assembly (such as 112) being rotatably supported on a cartridge bearing (such as 142) which has an outer housing (such as 146) rotatably supported about a stationary shaft (such as 144) secured between a base deck (such as 102) and a top cover (such as 104). A disc pack assembly comprising a number of discs (such as 108) supported by a spindle motor (such as 106) is likewise supported by the base deck and top cover and interacts with the actuator assembly to read and write data to the discs.

The actuator assembly has an E-block (such as 115) which has a bore (such as 138) which is sized to receivingly engage the cartridge bearing. The bore has a pair of alignment edges (such as 154) and one or more fasteners (such as 143) threadingly engaging the cartridge bearing when the E-block is attached to the cartridge bearing.

The fasteners pressingly engage the cartridge bearing against the alignment edges resulting in a line contact between the cartridge bearing and the E-block, with clearance therebetween elsewhere about the perimeter of the cartridge bearing. A canted coil spring (such as 156) is receivingly disposed in a groove (such as 158) in the housing of the cartridge bearing, the canted coil spring appropriately sized so as to fill the clearance gap between the cartridge bearing and the E-block, thus supporting the E-block in a resilient manner by the canted coils of the coil spring.

It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with details of the structure and function of various embodiments of the invention, this disclosure is illustrative only, and changes may be made in details especially in matters of structure and arrangement of parts within the principles of the present invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A pivot mechanism for an actuator assembly of a disc drive to permit rotational motion of an E-block of the actuator assembly, the pivot mechanism comprising:

a cartridge bearing supporting the E-block; and

a canted coil spring supported by the cartridge bearing and interposed between the cartridge bearing and the E-block so as to compensate for thermal expansion while minimizing overshoot conditions.

2. The pivot mechanism of claim 1 wherein the cartridge bearing has a peripheral groove for receiving disposition of the canted coil spring.

3. The pivot mechanism of claim 2 wherein the E-block has a bore having an alignment edge, and wherein the cartridge bearing further comprises an upper shoulder and a lower shoulder which operably engage the alignment edge.

4. The pivot mechanism of claim 3 further comprising a fastener which urges the cartridge bearing into pressing engagement with the alignment edge.

5. The pivot mechanism of claim 4 wherein the canted coil spring comprises a plurality of upstanding spiral wound coils that pressingly engage both the cartridge bearing and the E-block to provide resilient support of the E-block.

6. The pivot mechanism of claim 5 wherein the spiral wound coils have a variable angular attitude with respect to the cartridge bearing and the E-block as a clearance gap between the cartridge bearing and the E-block varies.

7. In a disc drive assembly having a base deck, a spindle motor supported by the base deck, a disc connected to the spindle motor for rotation and having a data surface, and a cover which cooperates with the base deck to provide a sealed enclosure, an improved actuator assembly comprising:

a cartridge bearing assembly supported by the base deck and cover;

a canted coil spring supported by the cartridge bearing, so as to compensate for thermal expansion while minimizing overshoot conditions; and

an E-block supported by the cartridge bearing and the canted coil spring.

8. The apparatus of claim 7 wherein the E-block has a bore which receivingly engages the cartridge bearing.

9. The apparatus of claim 8 wherein the bore of the E-block forms an alignment edge.

10. The apparatus of claim 9 wherein the cartridge bearing has an upper shoulder portion and a lower shoulder portion, wherein the shoulder portions operably engage the alignment edge of the E-block bore.

11. The apparatus of claim 10 further comprising a fastener that pressingly engages the cartridge bearing against the alignment edge.

12. The apparatus of claim 11 wherein the cartridge bearing has a peripheral groove for receiving disposition of the canted coil spring.

13. The pivot mechanism of claim 12 wherein the canted coil spring comprises a plurality of upstanding spiral wound coils that pressingly engage both the cartridge bearing and the E-block to provide resilient support of the E-block.

14. The pivot mechanism of claim 13 wherein the spiral wound coils have a variable angular attitude with respect to the cartridge bearing and the E-block as a clearance gap between the cartridge bearing and the E-block varies.

15. A disc drive assembly, comprising:

a base deck;

a cover;

a spindle motor supported by the base deck and cover;

a disc rotatably supported by the spindle motor, the disc having a data recording surface;

an actuator assembly supporting a read/write head for reading and writing data to the disc; and

a pivot shaft bearing assembly comprising a cartridge bearing supported by the base deck and the cover and a canted coil spring supported by the cartridge bearing so as to compensate for thermal expansion while minimizing overshoot conditions.

16. The disc drive assembly of claim 15 wherein the actuator assembly further comprises an E-block supported by the cartridge bearing and the canted coil spring, wherein the canted coil spring is interposed between the cartridge bearing and the E-block.

17. The disc drive assembly of claim 16 wherein the E-block has a bore for receiving disposition of the cartridge bearing, the bore having an alignment edge which operably engages the cartridge bearing.

18. The disc drive assembly of claim 17 wherein the canted coil spring comprises a plurality of upstanding spiral wound coils that pressingly engage both the cartridge bearing and the E-block to provide resilient support of the E-block.

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19. A pivot mechanism for an actuator assembly of a disc drive to permit rotational motion of an E-block of the actuator assembly, the pivot mechanism comprising:
a cartridge bearing; and

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means for supporting the E-block interposed between the cartridge bearing and the E-block.

* * * * *



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United States Patent [19]

Brar et al.

[11] **Patent Number:** 5,156,919[45] **Date of Patent:** Oct. 20, 1992

[54] **FLUOROCARBON COATED MAGNESIUM ALLOY CARRIAGE AND METHOD OF COATING A MAGNESIUM ALLOY SHAPED PART**

[75] **Inventors:** Amarjit S. Brar, Edina, Minn.;
Prativadi B. Narayan, Bloomfield, Colo.

[73] **Assignee:** Segate Technology, Inc., Scotts Valley, Calif.

[21] **Appl. No.:** 504,344

[22] **Filed:** Apr. 3, 1990

[51] **Int. Cl.:** B32B 15/08

[52] **U.S. Cl.:** 428/463; 204/58.4; 204/192.12; 204/169; 204/170; 360/102; 360/106; 360/126; 427/490; 428/421; 428/938

[58] **Field of Search:** 428/621, 622, 625, 649; 428/900, 928, 938, 457, 461, 463, 421, 422; 427/34, 41; 204/58.4, 192.12, 192.16, 169, 170; 360/102-106, 126

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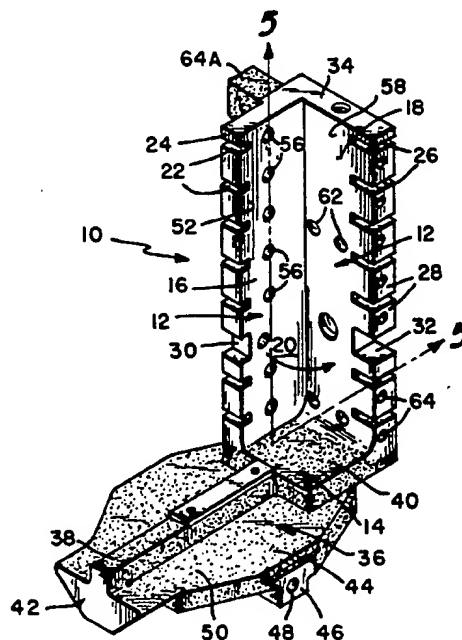
Primary Examiner—Paul J. Thibodeau

Assistant Examiner—Hoa T. Le

Attorney, Agent, or Firm—Kinney & Lange

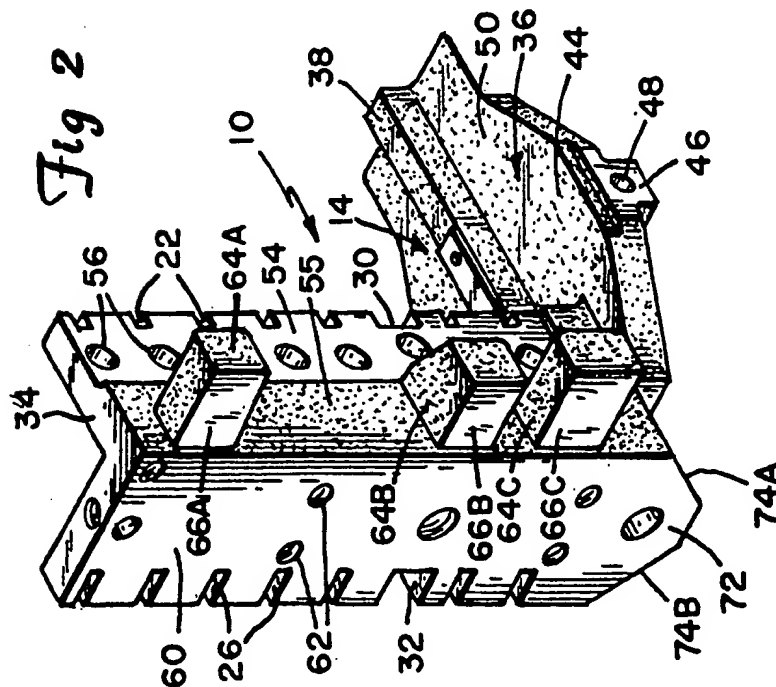
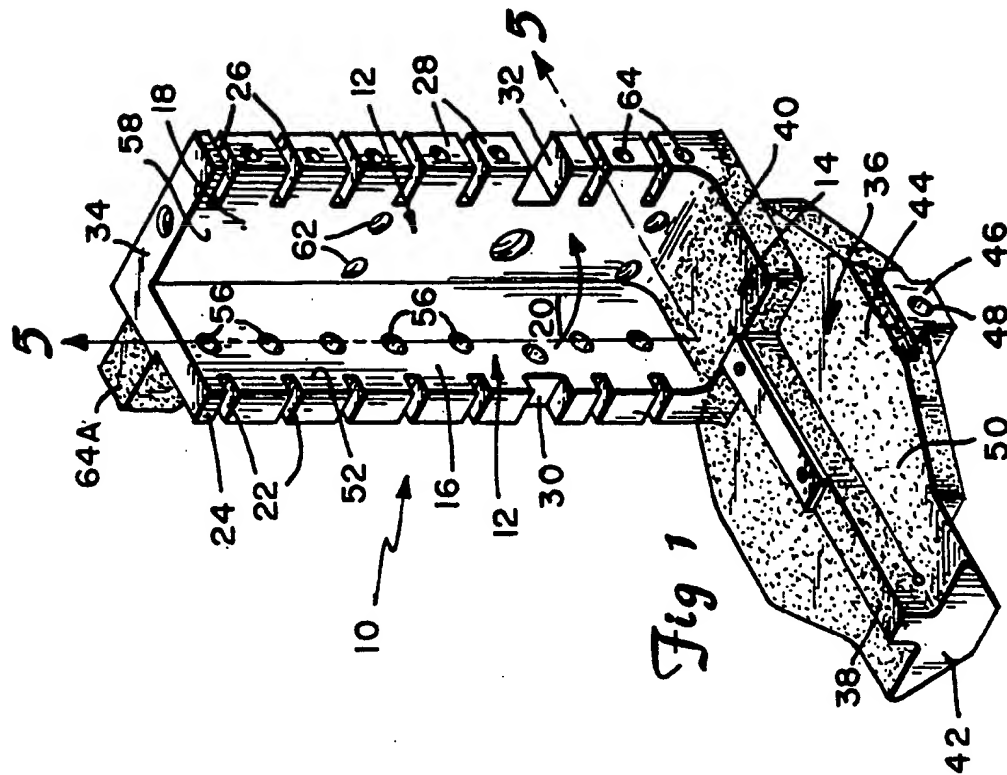
[57] ABSTRACT

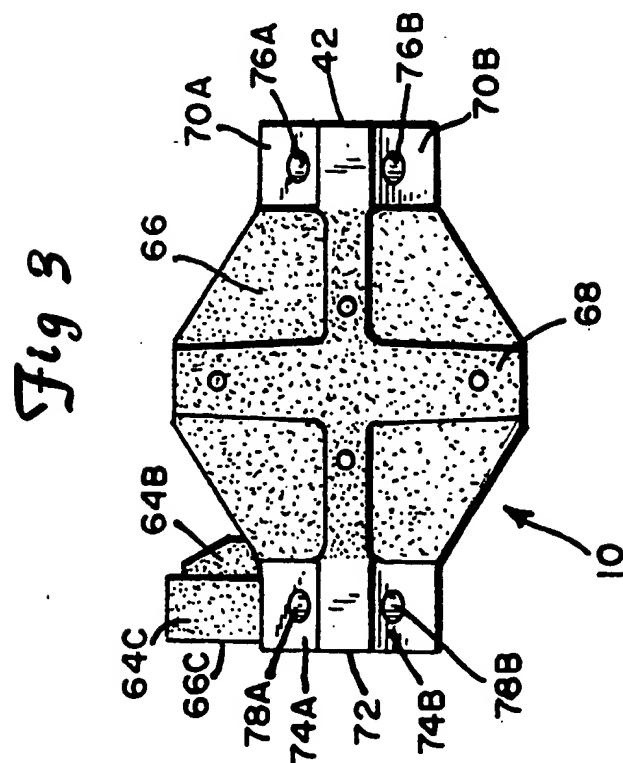
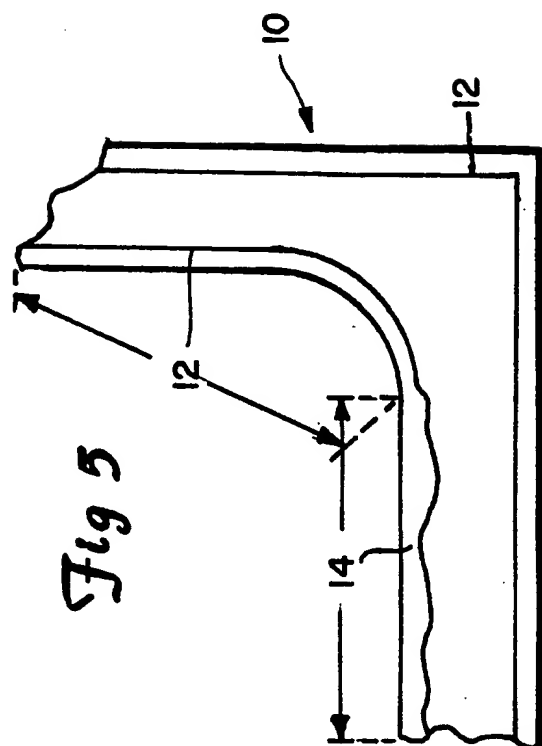
A magnesium alloy structural member for supporting at least one actuator arm in a hard disk drive and a method for making a shaped magnesium part having a fluorocarbon coating is disclosed. The coating is applied by exposing the member to a reactive gas in the presence of a glow discharge plasma to prevent corrosion. The glow discharge is generated by providing a vacuum environment at a pressure of between 250 and 300 millitorr in a reaction chamber and applying power to a pair of electrodes contained within the reaction chamber. Power is supplied at between about 100 and about 200 watts at about 13.6 megahertz, forming a low temperature glow discharge plasma. A reactive gas comprising a fluorinated alkane is introduced to the reaction chamber, and a pressure of between about 100 and about 300 millitorr is maintained. The structural member is exposed to the reactive gas and the plasma for an amount of time sufficient to form a thin and uniform polymeric fluorocarbon coating on the surface of the part. After the coating is formed, the chamber is purged with a hydrocarbon gas to consume any fluorine free radicals.

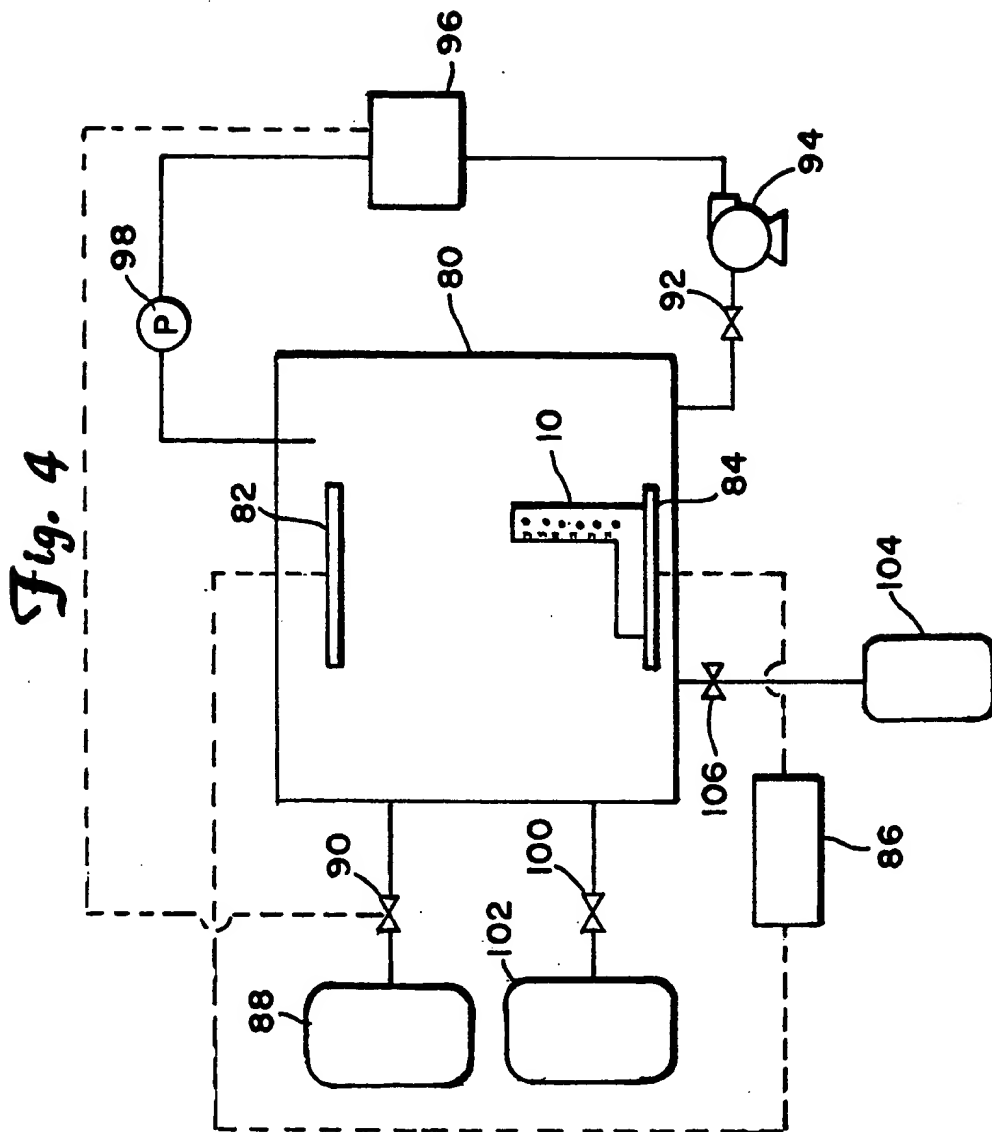
31 Claims, 3 Drawing Sheets**EXHIBIT**

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FLUOROCARBON COATED MAGNESIUM ALLOY CARRIAGE AND METHOD OF COATING A MAGNESIUM ALLOY SHAPED PART

BACKGROUND OF THE INVENTION

The present invention relates to corrosion protection. In particular, it relates to corrosion protection of mechanical parts used in the manufacture of computer disk drives.

A computer hard disk drive typically has at least one disk having a magnetic recording surface, and a magnetic transducer for reading information from the disk and writing information onto the disk. When the disk drive is in operation, an air cushion forms between the disk and the transducer. Due to the air cushion, the transducer flies at a distance called "flying height" by computer component manufacturers. The flying height in a high performance disk drive is typically about 5 microinches to about 15 microinches (1,270-3,810 angstroms) above a spinning hard disk.

If any particulates come between the disk and transducer, the transducer may become aerodynamically unstable. This instability eventually leads to catastrophic head crash.

Repair of crashed hard drives at this time is not economical. A hard disk drive that has experienced a head crash must typically be replaced. Thus, it is essential to address all potential sources of contamination in a hard disk drive. For this reason, hard disk drive components are manufactured and assembled in a very clean environment, referred to as a "white room environment" to workers skilled in the art.

The materials used to construct individual parts of a hard disk drive may also contaminate the drive and cause head crash. Some metals used in forming mechanical parts corrode when exposed to the atmosphere. The corrosion generates particulates such as powder and flakes which break off and interfere with disk drive performance.

Anticorrosive coatings have been applied to the metal parts to inhibit corrosion. These coatings can flake or chip off and contaminate the disk drive. Coatings that are applied to parts to improve wear resistance and increase lubricity, for example, can also ultimately cause component failure if the coating flakes off.

It is essential to select materials in forming individual disk drive components which do not eventually contaminate the assembled hard disk drive.

High performance hard disk drives typically have a number of recording disks, and a number of actuator arms for supporting a number of magnetic read/write transducers near the disk surfaces. All of the actuator arms in the disk drive are supported by a single actuator arm carriage.

The carriage rapidly moves each actuator arm in unison during disk drive operation. Adequate mechanical performance of the carriage is heavily dependent upon the material selected to construct the part. The carriage must be constructed of a material that is rigid, is very light in weight, and has a high modulus of elasticity. Carriages known in the art are built of aluminum metal alloys, and magnesium metal alloys.

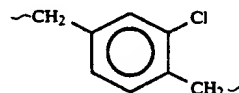
Aluminum alloys such as Alloy 356 (sand cast alloy) and Alloy 360 and 380 (die cast alloys) each have a suitable modulus of elasticity, (i.e.—between about 10.3 million and 10.5 million pounds per square inch) but have densities which provide excessive mass to the

carriage/actuator arm assembly. Magnesium alloys such as Alloy AZ91B (die cast material), Alloy AZ91C (sand cast material) and AZ31B (wrought material) have a slightly lower modulus of elasticity (i.e.—about 6.5 million pounds per square inch) and are much less dense. A material having a modulus of elasticity of about 6.5 million p.s.i. is still suitable for forming a carriage.

It is estimated that carriages built of the magnesium alloys mentioned above have a mass which is about 65 percent of the weight of a 360 aluminum alloy, for example. A weight reduction of this magnitude allows the carriage/actuator assembly to accelerate much more rapidly, and provides more rapid operation of the hard disk drive. From the standpoint of its mechanical characteristics, the most preferred material for constructing actuator arm carriages is magnesium alloy AZ91B. Alloy AZ91B contains aluminum in an amount of about 9 percent by weight, zinc in an amount of about 1 percent by weight, and manganese in an amount of about 0.2 percent by weight. The balance is magnesium.

Although magnesium alloy AZ91B exhibits superior mechanical characteristics, it is highly reactive with atmospheric constituents. Atmospheric constituents such as oxygen, moisture and chlorine are known to react with the alloy. In particular, AZ91B alloy rapidly corrodes in the presence of oxygen and moisture. Magnesium also reacts with chlorine present in the air, forming magnesium chloride. Corrosion products, such as magnesium oxide and magnesium chloride, for example, flake off and form particulates which are known to cause head crashes.

In order to take advantage of the superior mechanical characteristics of magnesium alloys, it is necessary to treat the surface of the carriage with an anticorrosive coating to prevent the formation of corrosion products. Various anticorrosive coatings have been applied to the exterior surfaces of the carriage. Presently, a Parylene-C coating is used as a corrosion inhibitor for alloy AZ91B. Parylene-C is available from the Nova Tran Corporation of Clear Lake, Wis. Parylene-C coating has the following chemical structure:



use, corrosion on the surfaces of the carriage is even more undesirable.

An adequate anticorrosive coating should be thick enough to prevent corrosion, but thin enough to avoid interfering with the conductive properties of the substrate. At thicknesses between about $\frac{1}{2}$ mil and about 1 mil (127,000 to 254,000 Angstroms), Parylene-C coatings failed to prevent corrosion in a period of time of less than one year. Because the useful life of a disk drive often exceeds one year, Parylene-C coating has proved to provide an unacceptable corrosion barrier.

Parylene-C coatings at thicknesses of between about $\frac{1}{2}$ mil to about 1 mil (127,000–254,000 angstroms) are also known to interfere with the conductive properties of the metal. At thicknesses within this range, the magnesium alloy substrate is less electrically conductive, and is not as capable of dissipating static as the substrate would be without the coating. Components which are not static dissipative are known to arc when subjected to a static charge. Arcing is known to damage the electrical components of the disk drive. The loss of conductivity also causes the substrate to attract particulates such as dust, which cause hard drive crashes.

Other organic coatings have been applied by various methods, such as electrostatic dipping for example, but have produced coatings which are generally too thick, and which vary greatly in thickness across the exterior surfaces of the part. These coatings also are of a thickness which interferes with the electrical properties of the substrate. For example, E-Coating, an epoxy product available from the Glidden Paint, Architectural Maintenance Company, Dublin, Ohio, is applied to carriages by an electrostatic method. E-Coating is generally too thick, and provides a coating which does not have a uniform thickness. Coatings which are too thick or which vary in thickness interfere with the close tolerances required in manufacturing the carriage. Typically the machined portions of the carriage require tolerances of plus or minus 0.003 inch.

Actuator arm carriages are formed by several methods. The carriages may be die cast, sand cast, or machined from wrought alloy. Die casting is the most desirable because the outer surfaces of the part are smoother, and require less machining to manufacture the finished part. Machining a part from wrought alloy is the least desirable because the procedure is time consuming and expensive. Sand casting is an acceptable method, but produces a part having exterior surfaces which are more rough than surfaces formed from a die cast method. The rougher surfaces require more machining, and are more costly to manufacture.

Machining magnesium metal, or magnesium metal alloys, requires an oxygen-free environment to avoid explosions. Also, because the metal is very hard, machining the carriages requires the use of very hard cutting tools.

After machining, the carriages are inspected for signs of corrosion, cleaned and coated with an anticorrosive coating. None of the anticorrosive coatings known in the art adequately prevent corrosion of the magnesium alloy carriage. None of the existing coatings are thin enough to avoid interfering with the close machine tolerances required in the manufacture of the part. None of the existing coatings are thin enough to avoid significantly diminishing the electrostatic properties of the metal. The prior art coatings also do not provide corrosion protection for the entire expected life of the hard disk drive.

SUMMARY OF THE INVENTION

The present invention is a mechanical part for use in a computer hard disk drive. The part is formed from a lightweight magnesium alloy that is substantially rigid, and is coated with a thin fluorocarbon coating which prevents corrosion of the exterior surfaces of the part. A mechanical part to which the present invention specifically relates is an actuator arm carriage which supports at least one actuator arm, and attached magnetic read/write (or servo) transducer.

The hard disk drive which incorporates an actuator arm carriage in accordance with the present invention includes a plurality of magnetic recording disks, and a plurality of magnetic transducers. The magnetic transducers cooperate with a magnetic disk surface, and read data from or write data on the disk surface. The carriage moves each actuator arm in unison which in turn moves each transducer from position to position on the disk surface.

The carriage of the preferred embodiment is formed of a very lightweight alloy including magnesium as the principal component. The alloy is very light in weight and has a modulus of elasticity between about 6.0 million and about 12.0 million p.s.i. The mechanical characteristics of the magnesium alloy allow the carriage/actuator arm assembly to rapidly accelerate, and quickly access data.

Magnesium is known to be very reactive with substances present in the atmosphere. The exposed surfaces of the carriage of the present invention are coated with an anticorrosive fluorocarbon polymer coating having a uniform thickness of between about 50 and about 500 angstroms. The thickness of the coating depends in part upon the surface roughness of the substrate.

The present invention also includes a method of forming a fluorocarbon coating on a magnesium alloy part. The coating is formed by placing a magnesium alloy substrate in a reaction chamber, providing a vacuum atmosphere of between about $1 \times 10^{10-6}$ and about 1×10^{-4} torr, and introducing an amount of argon gas sufficient to raise the pressure to about 250–300 millitorr. Power is provided to a pair of electrodes positioned in the reaction chamber at between about 100 and about 200 watts, at about 13.6 megahertz, forming a glow discharge plasma. The flow of argon gas is shut off. Then, a reactive gas comprising a fluorinated alkane is introduced into the reaction chamber. The most preferred reactive gas is carbon tetrafluoride. An amount of reactive gas sufficient to maintain the pressure in the reaction chamber at between about 100 and about 300 millitorr is introduced into the chamber. The substrate is exposed to the reactive gas and the glow discharge plasma for an amount of time sufficient to form a very thin fluoropolymer coating on the surfaces of the substrate. Following the exposure of the part to the reactive gas, the reaction chamber is flushed with a purge gas comprising a gaseous hydrocarbon for an amount of time sufficient to form a substantially nonreactive outer surface on the fluorocarbon coating.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a first perspective view of an actuator arm carriage in accordance with the present invention.

FIG. 2 is a rotated perspective view of the actuator arm carriage of FIG. 1.

FIG. 3 is a bottom plan view of the actuator arm carriage of FIGS. 1 and 2.

FIG. 4 is a schematic diagram of an apparatus for carrying out the coating method of the present invention.

FIG. 5 is a cross-sectional view of an actuator arm carriage, taken along line 5—5 in FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides an actuator arm carriage formed from a magnesium metal alloy for use in a hard disk drive of a computer. The outer surfaces of the carriage are coated with fluorinated polymer. The present invention also includes a method of applying a fluorocarbon coating to a substrate formed from a magnesium alloy. A "magnesium alloy" for purposes of this disclosure is a substantially solid mixture of metals comprising greater than 50 percent magnesium metal.

FIG. 1 illustrates an actuator arm carriage 10 in accordance with the present invention. The carriage 10 is used to support a plurality of actuator arms (not shown) in a position which is substantially parallel to a plurality of hard disk surfaces in a disk drive (not shown).

In the preferred embodiment, the carriage 10 is formed from magnesium alloy AZ91B (die cast alloy). AZ91B Alloy contains aluminum in an amount of about 9 percent by weight, zinc in an amount of about 1 percent by weight, and manganese in an amount of about 0.2 percent by weight. The balance is magnesium. Magnesium alloy AZ91B is the most preferred material for forming the actuator arm carriage 10 because the material is extremely light in weight, and has a high modulus of elasticity. The reduced weight minimizes the inertia of the carriage/actuator arm assembly while the disk drive is in operation. A high modulus of elasticity allows the carriage to rapidly return to its original shape after deflection.

Alloys in accordance with the present invention are selected based on the density of the metal, and the modulus of elasticity. Magnesium is a metal which has a density which is approximately 65 percent of the density of aluminum. A modulus of elasticity between about 6.0 million and about 12.0 million pounds per square inch (psi) is a suitable performance characteristic for a material used to form an actuator arm carriage. The most preferred magnesium alloy, AZ91B has a modulus of elasticity of about 6.5 million psi.

Magnesium alloys have the added advantage of being electrically conductive.

Although a magnesium alloy containing small amounts of zinc and aluminum form the most preferred carriage 10, other magnesium-containing metals such as Alloy AZ31 having a modulus of elasticity in the range of about 6.0 million psi to about 12.0 million psi are suitable materials for forming the carriage 10.

The carriage 10, formed in accordance with the most preferred embodiment, is formed by a die cast method, and is then machined to very small dimensional tolerances. The illustrated carriage 10 is machined to a tolerance of about ± 0.003 inch in each direction. The precise dimensions of the carriage 10 are dependent upon the size and characteristics of the disk drive, and are not critical to the present invention. In accordance with a second preferred embodiment, the carriage 10 is sand cast. A carriage 10 formed by either die casting or sand casting has smooth machined surfaces (surface 12, for example), and more rough cast surfaces (surface 14, for example).

The parts are machined in an oxygen-free environment to prevent sparking or explosions. Because magnesium alloys are very hard, it is necessary to select tooling machinery which is capable of cutting magnesium.

In the illustrated embodiment, the carriage 10 includes first and second substantially flat vertical members 16 and 18 intersecting at an angle 20 of about ninety degrees. The vertical members 16 and 18 form an inner corner for receiving a substantially rectangular edge portion of an actuator arm (not shown). The overall height of the carriage 10 measured along an edge 24 of the first vertical member 16 is about $3\frac{1}{2}$ inches. The width of each vertical member 16 and 18 is about $\frac{1}{4}$ of an inch, measured along the front surfaces 52 and 58. A plurality of small notches 22 are cut horizontally into an edge 24 of the first vertical member 16, and a plurality of small notches 26 are cut horizontally into the edge 28 of the second vertical member 18. In the preferred embodiment, seven notches 22 having a depth (measured horizontally in FIG. 1) of about $\frac{3}{16}$ of an inch, and having a width (measured vertically in FIG. 1) of about $\frac{1}{16}$ inch are cut into the first vertical member 16, and seven notches 28 of substantially the same size as the notches 22 are cut into the second vertical member 18.

The first vertical member 16 also has a larger notch 30 having a depth of about $\frac{3}{16}$ and a width of about $\frac{1}{4}$ inch cut into the edge 24, proximate the center of the vertical member 16. The second vertical member 18 also has a larger notch 32 cut into the edge 28 of substantially the same size as notch 30, and which is positioned vertically the same distance from the upper edge 34 of the carriage 10 as the distance from the notch 30 to the top edge 34.

The carriage 10 has a base member 36 which has a cast finish. The base member 36 has a machined central rail 38 extending from the base of a raised, substantially square platform 40 formed by the intersection of horizontal members 16 and 18, to the end 42 opposite the platform 40. The upper surface of the platform 40 has a cast finish, and the rail 38 is about 2 inches in length.

The base member 36 has a central portion 44 which is wider than the width of the base near the end 42 or near the platform 40. The central portion 44 has a side edge 46 which is machined and has a cylindrical shaped aperture 48 extending from the side edge 46 into a portion of the base member 36.

The cast surfaces 50 of the base member 36 are die cast and are rough compared to the roughness of the machined surfaces 38 and 46, for example.

The front surface 52, a portion of the back surface 54 (shown in FIG. 2), the top edge 34 and the side edge 24 of the first vertical member 16 are substantially flat machined surfaces. A plurality of apertures 56 extend through the first vertical member 16, intersecting the front surface 52 and back surface 54 (shown in FIG. 2). There are eight apertures 56 in the example shown in FIG. 2. Each aperture 56 is of the same size (about $\frac{1}{4}$ inch), and has an inner surface which is substantially cylindrical and smooth.

The second vertical member 18 also has a machined front surface 58, a machined rear surface 60 (shown in FIG. 2), and a plurality of apertures 62 extending through surfaces 58 and 60. There are five apertures 62 in the embodiment shown in FIG. 2, each having a threaded interior surface. One aperture in the preferred embodiment is located centrally on the second vertical member 18 and is about $\frac{1}{4}$ inch inner diameter in size. The remaining apertures 62 are spaced around the

larger aperture and have openings of about 3/32 of an inch.

The side edge 28 of the vertical member 16 is cut into substantially rectangular surfaces, most of which have a plurality of threaded apertures 64 extending into a portion of the second vertical member 18. In the preferred embodiment, there are seven apertures 64 of about a 1/32 inner diameter in size.

FIG. 2 is a second perspective view of the carriage 10 as viewed from a direction 180 degrees from the view illustrated in FIG. 1. There are three projections 64A, 64B and 64C extending outwardly from surface 55. The surfaces 66A, 66B and 66C are substantially parallel to the surface 60 in the preferred embodiment and are machined. The rest of the surfaces of the projections 64A, 64B and 64C have a cast finish.

FIG. 3 is a bottom plan view of the carriage 10. The carriage 10 has a lower cast finished surface 66 and a raised machined surface 68 defining the lowermost portion of the carriage. Near the end 42 are a pair of machined tapered surfaces 70A and 70B which intersect the raised machine surface 68. At the end 72 opposite the end 42 are a second pair of tapered machined surfaces 74A and 74B. Intersecting each tapered surface 70A, 70B, 74A, and 74B in the preferred embodiment are cylindrical apertures 76A, 76B, and 78A, and 78B, each having an axis which is substantially perpendicular to the tapered surfaces 70A, 70B, 74A, and 74B, respectively. In the preferred embodiment, the cylindrical apertures 76A, 76B, 78A, and 78B have smooth inner surfaces.

The carriages 10 are cast, machined, and then coated with conventional machine oil to prevent corrosion of the exposed surfaces. The machine oil remains on the outer surfaces of the carriages 10 until shortly before applying the fluorocarbon coating of the present invention. Because the machine oil does not completely prevent corrosion, the preferred method of forming a coated carriage 10 includes minimizing the amount of time which elapses between machining and coating. The time between machining and coating according to the preferred method is no greater than eight hours.

Immediately before applying the fluorocarbon coating of the present invention, the carriages 10 are cleaned in an ultrasonic bath containing Freon TMS, a solvent available from the E. I. Du Pont de Nemours, Co. of Wilmington, Del., or in a suitable equivalent such as Freon TF (also available from Du Pont), for example. The solvent must be capable of dissolving machine oil and organic contaminants. The carriages 10 are cleaned for a period of at least five minutes up to several hours to remove all but a trace amount of machine oil. The preferred cleaning time is about five minutes. The carriages 10 are then quickly dried in a conventional manner, such as in an inert nitrogen environment to prevent oxidation.

The carriages 10 are next inspected for signs of corrosion. Any black, gray or white streaking on the surfaces of the carriage 10 indicates that corrosion has occurred. It is necessary to remove this corrosion before applying the coating of the present invention to obtain adequate adherence of the coating to the metal surfaces. The preferred method of cleaning the corroded surfaces is by exposing the carriage 10 to a low temperature plasma according to the method which is described below.

A schematic diagram of the apparatus for carrying out the method of the present invention is illustrated in

FIG. 4. The apparatus includes a reaction chamber 80 which is large enough to contain at least one substrate to be coated. Although the present method is not limited to coating a carriage 10, the carriage 10 is one example of a shaped mechanical part. The chamber according to the preferred method is about 12"×12"×12", and large enough to contain only one carriage 10. The present method may be carried out in any size chamber with any number of shaped parts which can be positioned in the reaction chamber. Within the reaction chamber 80 are a pair of electrodes 82 (anode) and 84 (cathode) for generating an electrical field in the reaction chamber 80.

A power supply 86 in the preferred embodiment is electrically connected to each electrode 82 and 84, and provides between about 100 and about 200 watts power to the electrodes 82 and 84. The most preferred power is supplied at about 150 watts. The power supply in the preferred embodiment is A.C., and is within the Radio Frequency (RF) range. The most preferred frequency is 13.6 megahertz. The carriage contacts the electrode 84 according to the most preferred method. This method is referred to as "inductive coupling", and is suitable for use with substrates which are electrically conductive. The carriage 10 is also positionable between electrodes 82 and 84, in a manner which is out of electrical contact with electrodes 82 or 84. This method is referred to as a "free floating" method. To obtain an electrical field of an intensity strong enough to carry out the present reaction by the free floating method, it is necessary to provide more power to the electrodes 82 and 84, such as 200 watts, for example. The present invention also contemplates alternative methods for generating an electrical field within the reaction chamber 80 such as by providing a coil around the exterior of the reaction chamber 80 (not shown).

If the substrate shows signs of corrosion, the carriage 10 is pretreated in the chamber by a "plasma etch" method to remove any deposits which may interfere with adhesion between the substrate surface and the anticorrosive coating of the present invention.

The plasma etch method includes a first step of flushing the reaction chamber 80 with argon gas supplied to the chamber 80 from a bottle 88 which is fluidly connected to the chamber 80. A valve 90 is opened, allowing argon to enter the chamber. An outlet valve 92 is also opened to allow the flush gas to escape. An amount of gas equal to at least six volumes of the reaction chamber 80 at standard conditions (S.T.P.) passes through the apparatus. Any amount of gas sufficient to eliminate the oxygen in the chamber 80 is adequate for flushing the chamber.

Then, the argon gas valve 90 is closed. A vacuum pump 94 cooperates with a pressure controller 96 and a pressure sensor 98, and lowers the pressure in the reaction chamber 80 to between about 1×10^{-6} and about 1×10^{-4} torr. The controller 96 is electrically connected to an actuator on the argon valve 90, and allows additional argon to enter the chamber 80 to maintain a pressure within the selected range.

Power between about 100 and about 200 Watts, with a preferred power of about 150 watts, at a frequency of about 13.6 megahertz (RF frequency) is applied to the cathode 84, forming a glow discharge plasma between the cathode 84 and the anode 82. Both the cathode 84 and the anode 82 are positioned within the chamber 80 according to the preferred method. The carriage 10 in the preferred method contacts the cathode 84, and is

inductively coupled to the cathode 84. The carriage 10 remains in the plasma for a period of between about 45 minutes to about 2 hours. The most preferred exposure time is about one hour. Exposure times within the stated time range remove substantially all of the oxidized metals, other corrosion products and a majority of other surface contaminants. Although argon is the most preferred gas, nitrogen gas may alternatively be used to plasma etch the substrate.

Although not critical to the present invention, the substrate (carriage 10) according to the present method during the "plasma etch" step does not exceed a temperature of about 100 degrees Centigrade at about 150 watts, and at about 13.6 megahertz frequency.

If the carriage shows no visible signs of corrosion, the "plasma etch" step may be skipped. Instead, the outlet valve 92 is opened, the argon supply valve 90 is closed, (the reactive gas valve 100 is also closed) and a vacuum pump 94 evacuates the chamber 80 until the pressure sensor 98 indicates to the controller 96 that a vacuum is present in the chamber in a preselected range of between about 1×10^{-4} and about 1×10^{-6} torr.

After either plasma etching, or pulling a vacuum between about 1×10^{-4} and 1×10^{-6} torr, the pressure controller 96 is reset to a pressure range of between about 250 and 350 millitorr. The controller 96 opens the argon supply valve 90, allowing argon gas stored in the bottle 88 to fill the reaction chamber 80, until the chamber 80 reaches the selected pressure.

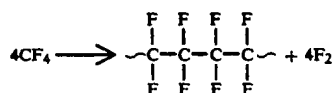
The argon supply valve 90 is closed, and the pressure controller 96 is reset to a selected pressure range of between about 100 to about 300 millitorr. A bottle of reactive gas 102 is fluidly connected to the reaction chamber 80. Reactive gas for purposes of this disclosure is a gas which reacts chemically on the surface of the substrate, forming a coating. The reactive gas supply valve 100 is opened, and reactive gas enters the reaction chamber 80 until the pressure sensor 98 in the reaction chamber 80 senses the selected pressure. The most preferred pressure for this step is about 250 millitorr. The anode 82 and cathode 84 remain energized while the reactive gas enters the reaction chamber 80.

The argon supply valve 90 according to the preferred method remains closed during the reaction. There is still an amount of unreactive argon gas present in the reaction chamber 80 during the coating process. Although the presence of argon is not critical to forming the fluorocarbon coating, it is believed that the large argon molecules bombard the surfaces of the carriage 10, heating the substrate to a temperature of about 100 degrees C which tends to drive the chemical reaction on the surface of the carriage 10 toward completion (polymerization). Any amount of argon up to about five mole percent enhances the polymerization. Alternatively, the reaction chamber 80 can be evacuated to between about 1×10^{-6} and about 1×10^{-4} torr and then filled with 100 percent reactive gas. The absence of the argon does not prevent the formation of a glow discharge plasma, or the commencement of the polymerization reaction.

The reactive gas used according to the present method is selected from the group comprising fluorinated alkanes. The most preferred reactive gas is carbon tetrafluoride. Carbon tetrafluoride in the presence of the plasma tends to lose at least one or two fluorine atoms, and is believed to form CF_3 + reactive species, as well as CF_2 + reactive species. Excess fluorine ions are a by-product of the polymerization.

Although the reaction mechanisms in forming the coating of the present invention are not precisely understood, it is believed that in order to initiate the polymerization, it is necessary to have a number of reactive carbon species present on the surface of the substrate. Surface contamination of the substrate from exposure to air, and residue from the machine oil earlier removed may provide a sufficient amount of reactive carbon on the surface of the substrate to commence the polymerization reaction. The first amounts of reactive gas introduced into the reaction chamber 80 may also provide a sufficient amount of reactive carbon species for initiating the polymerization reaction.

In the most preferred embodiment, an extended chain, fully saturated hydrocarbon having essentially the following formula forms on the surface of the substrate:



The reaction of the preferred method is believed to form a tough, corrosion resistant coating which comprises essentially polymerized carbon and fluorine atoms. The composition of the coating of the preferred embodiment was verified by Electron Spectroscopy for Chemical Analysis (ESCA) techniques known in the art. The gas which exits the reaction chamber 80 is rich in fluorine gas.

Although the exact mechanism of the reaction is not precisely understood, it is believed that the polymerization occurs completely on the surface of the substrate, and that the polymer becomes chemically bonded to the surface. The bonding of the metals in the selected magnesium alloy to the reactive species is believed to be one of the reasons why the coating of the present invention has superior corrosion resistance.

Although CF_4 is the most preferred reactive gas for use with the present method, many other reactive gases, including gas mixtures form suitable fluorocarbon coatings. C_2H_6 , C_3H_8 , CHF_3 , CF_3 , F_2 and $CHCF_3$, for example, which are formed primarily from carbon and/or fluorine are suitable reactive gasses. Also, mixtures of two or more of the above mentioned gasses also form a suitable reactive gas. For example, a mixture of CF_4 and fluorine gas produces a coating of essentially the same composition as shown by the reaction, above.

When selecting the reactive gas, it is critical to maintain the atomic ratio of carbon atoms to fluorine atoms at or below about 1:2. By maintaining the carbon to fluorine ratio at or below 1:2, a fully saturated polymer having the structure shown above is formed. Maintaining a C:F ratio in the gas which is less than or equal to the C:F ratio in the desired polymer drives the reaction in the direction of saturating the polymer with fluorine atoms.

The substrate 10 is exposed to the glow discharge plasma and the reactive gas for a period of about 45 minutes to about 2 hours. Because the process of forming this coating is a vapor deposition method, a coating having a substantially uniform thickness is formed. The most preferred exposure time is about 60 minutes. Exposures within the stated range produce coatings having a thickness of between about 50 and about 500 angstroms. Fluorocarbon coatings having thicknesses between

about 50 and about 500 angstroms do not significantly change the electrical conductivity of the substrate, and do not cause the shaped part to attract particulates. Mechanical parts having dimensional tolerances of about ± 0.003 inch are not changed enough by applying coatings having a thickness between about 50 and about 500 angstroms to cause quality control rejections due to size.

FIG. 5 shows a cross-sectional view of the carriage 10 after the coating step taken along line 5—5 in FIG. 1. The rough cast surfaces 14, as well as the machined surfaces 12 are coated with a substantially uniform fluoropolymer coating having a thickness between about 50 and about 500 angstroms, with a preferred thickness of about 100 angstroms.

It was surprisingly discovered that a polymer formed on the surface of a magnesium alloy according to the method described above is highly reactive. In particular, the coating readily absorbs water which causes corrosion in the underlying metal. In order to eliminate the surface reactivity, the present method includes a final step of purging the reaction chamber 80 as shown in FIG. 4 with a purge gas containing a hydrocarbon, such as methane. Other gasses such as ethane, propane and butane, for example, also are suitable purge gasses. The purge gas may also be a mixture of a hydrocarbon and an inert gas such as argon or nitrogen, for example. The most preferred purge gas is pure methane. A bottle of methane 104 according to the preferred method is fluidly connected to the reaction chamber 80 and supplies the purge gas.

To begin the purging process, the reaction chamber is evacuated to between about 400 and about 500 millitorr. The gas supply valve 100 is closed, and the outlet valve 92 is open during evacuation. A vacuum pump 94 removes gas from the reaction chamber 80. The purge gas valve 106 is then opened, and the reactive gas is allowed to enter the reaction chamber 80. The reactive gas supply valve 100 and the argon supply valve 90 remain closed during this step. Power to the anode 82 and cathode 84 is shut off. However, the cathode may remain energized. It is believed that the purging step is mainly a diffusion step, and the presence of glow discharge is not necessary to cause the fluorine-containing radicals to diffuse.

The vacuum pump 94 maintains a vacuum of approximately 400 millitorr while the purge gas is passing through the chamber 80. By purging the chamber 80, the purge gas contacts the surface of the carriage 10, and consumes any available reactive fluorine radicals. Fluorinated hydrocarbon gasses are purged out of the chamber 80, and the surface energy of the resulting coating is substantially reduced. It is believed that this step does not add additional thickness to the coating, and does not alter the composition of the coating.

A fluorinated hydrocarbon coating having the composition shown above, and having a thickness between about 50 and about 500 angstroms on the average has about 12 molecular layers. If the composition of the coating is altered slightly by the purging step, only the outermost molecular layer is chemically changed. The remaining layers of molecules are substantially of the formula provided above. It is possible that a very small percentage of the reacted fluorine atoms in the outermost layer of the coating would be replaced with hydrogen atoms.

The carriage 12 is exposed to a purge gas for a period of between about ten and about 15 minutes. The mini-

mum exposure time is about ten minutes, and an exposure time of about 15 minutes is preferred.

The resulting coating formed on the exposed surfaces of the carriage 10 has a very low surface energy, which has a very low reactivity to many substances. In particular, the coating of the present invention is substantially resistant to water, and many contaminants in the atmosphere such as chlorine and oxygen, which rapidly react with magnesium. The coating of the present invention is also very tough, scratch-resistant and smooth.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What is claimed is:

1. An actuator arm carriage for supporting an actuator arm in a magnetic disk drive, the actuator arm carriage comprising:

a carriage body having a shaped exterior surface that is susceptible to corrosion, wherein the body is formed from a magnesium alloy in which magnesium is a principal component; and

a polymeric film consisting essentially of extended chain fluoropolymers in direct contact with and coating the exterior surface of the body, the film having a thickness sufficient to inhibit corrosion of the carriage body caused by reaction of magnesium with substances in an atmosphere surrounding the carriage.

2. The carriage of claim 1 wherein the magnesium alloy has a modulus of elasticity between about 6.0 million and about 12.0 million psi.

3. The carriage of claim 2 wherein the magnesium alloy includes zinc in an amount of about 1% by weight, aluminum in an amount 9% by weight, and manganese in an amount of about 0.2% by weight.

4. The carriage of claim 1 wherein the coating is a substantially saturated fluorocarbon polymer, having a C:F atomic ratio of about 1:2.

5. The carriage of claim 1 wherein the polymeric film is between about 50 and about 500 angstroms thick.

6. The carriage of claim 1 wherein the body is formed by a die cast method.

7. The carriage of claim 1 wherein the body is formed by a sand cast method.

8. A method of inhibiting corrosion of a shaped mechanical part having exterior surfaces which are formed from a magnesium metal alloy comprising the steps of: positioning the part in a reaction chamber, the reaction chamber having an anode and a cathode; providing a vacuum at an initial pressure between about 250 and about 300 millitorr;

forming a glow discharge plasma with a power supply to the anode and cathode of between about 100 and about 200 Watts, and at a frequency of about 13.6 megahertz;

introducing a reactive gas comprising fluorinated alkanes to the reaction chamber, wherein the gas pressure is maintained between about 100 to about 300 millitorr;

exposing the exterior surfaces to the reactive gas and plasma for an amount of time sufficient to form a polymeric film covering the exterior surfaces which are in direct contact with and formed from a magnesium metal alloy, the polymeric film consisting essentially of extended chain fluoropolymers; and

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exposing the exterior surfaces to a purge gas comprising at least one hydrocarbon for an amount of time sufficient to form a coating capable of protecting the mechanical part from atmospheric corrosion.

9. The method of claim 8 and further comprising the step of providing an argon atmosphere at a pressure of between about 250 and about 300 millitorr prior to introducing the reactive gas.

10. The method of claim 8 wherein the shaped mechanical part contacts the cathode while the part is being exposed to the reactive gas.

11. The method of claim 10, wherein the shaped mechanical part is inductively coupled to the cathode.

12. The method of claim 8, wherein the shaped mechanical part is out of physical contact with the anode and cathode, and the part is positioned substantially between the anode and cathode.

13. The method of claim 8 wherein power is supplied at about 150 watts.

14. The method of claim 8 wherein the exterior surfaces are exposed to the reactive gas for between about 45 minutes and about 2 hours.

15. The method of claim 14 wherein the surfaces are exposed for about an hour.

16. The method of claim 8 wherein the pressure in the chamber is at about 250 millitorr pressure when the part is being exposed to the reactive gas.

17. The method of claim 8 wherein the fluorinated alkane is CF_4 .

18. The method of claim 8 wherein the reactive gas is a mixture of CF_4 and F_2 .

19. The method of claim 8 and further comprising the step of exposing the part to an argon glow discharge plasma prior to exposing the exterior surfaces to the

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reactive gas for between about 45 minutes and about 2 hours for cleaning the outer surfaces.

20. The product of the process of claim 8.

21. The product of claim 20, wherein the coating thickness is between about 50 and about 500 angstroms.

22. The method of claim 8 wherein a pressure sensor and pressure controller maintain a selected pressure in the chamber.

23. The method of claim 8 wherein prior to positioning the part in the reaction chamber, the exterior surfaces are coated with machine oil immediately after forming the part to inhibit environmental corrosion.

24. The method of claim 23 wherein after contacting the exterior surfaces with oil, the part is washed in an ultrasonic bath containing a solvent, for removing all but trace amounts of machine oil.

25. The method of claim 8 wherein the fluorinated alkane is carbon tetrafluoride.

26. The method of claim 8 wherein the ratio of carbon atoms to fluorine atoms in the reactive gas is less than or equal to about one carbon atom per two fluorine atoms.

27. The method of claim 8 wherein the magnesium containing part is formed from Alloy AZ91B.

28. The method of claim 8 wherein the magnesium containing part is formed from Alloy AZ31B.

29. The method of claim 8 wherein the purge gas is methane.

30. The method of claim 8 wherein after the coating is formed, the power to the electrodes is shut off, and a vacuum between about 400 and about 500 millitorr is provided before introduction of the purge gas.

31. The method of claim 29 wherein a pressure of about 400 millitorr is maintained for a period of between about ten and about fifteen minutes during the purging step.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,156,919

DATED : October 20, 1992

INVENTOR(S) : AMARJIT S. BRAR, PRATIVADI B. NARAYAN

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

ON THE TITLE PAGE:

Delete (73) Assignee: Segate Technology, Inc., Scotts Valley, Calif.

Insert (73) Assignee: Seagate Technology, Inc., Scotts Valley, Calif.

Signed and Sealed this
Twelfth Day of October, 1993

Attest:



BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks